PESTICIDE EXPOSURE AND ADVERSE HEALTH EFFECTS IN MALAYSIAN FARMERS

A thesis submitted to the University of Manchester for the degree of Doctor of Philosophy (PhD) in the Faculty of Biology, Medicine and Health Sciences.

2021

Zulkhairul Naim Bin Sidek Ahmad

School of Health Sciences
Division of Population Health, Health Services Research and Primary Care
Centre for Epidemiology
Centre for Occupational and Environmental Health

TABLE OF CONTENTS

(Word count- 58,894 words)

LIST OF TABLES

LIST OF FIGURES

LIST OF ABRREVIATIONS

A

AChE	Acetylcholinesterase
AD	Alzheimer Disease
AHS	Agricultural Health Study
ANOVA	One-way analysis of variance
AOPI	Acute occupational pesticide related illness
APP	Acute pesticide poisoning

B

BChE	Butyrylcholinesterase
BMI	Body Mass Index

C

cDCVA	cis-3-(2,2-dichlorovinyl)-2,2,dimethylcyclopropane carboxylic acid
CNS	Central nervous system
COSHH	Control of Substances Hazardous to Health

D

DAP	Dialkylphosphate metabolites
DBVA	3-(2.2-dibromovinyl)-2.2-dimethylcyclopropane
DDT	Dichlorodiphenyltrichloroethane
DEDTP	Diethyldithiophosphate
DEP	Diethylphosphate
DERM	Dermal Exposure Ranking Method
DETP	Diethylthiophosphate
DMDTP	Dimethyldithiophosptate
DMP	Dimethylphosphate
DMTP	Dimethylthiophospahte
DREAM	Dermal Exposure Assessment Method

E

EFS	Ethiopian Farmer Study

G

GABA	Gamma-Aminobutyric acid
GAP	Good Agricultural Practices
GDP	Gross Domestic Product

H

HSL	Health Safety Laboratory

I

ICC	Intraclass correlation coefficient

L

LC-MS	Liquid chromatography- mass spectrometry
LD50	Lethal dose
LMICs	Lower and middle-income countries

M

MeSH	Medical subject headings

N

NOS	Newcastle Ottawa Scale

O

OC	Organochlorine
OP	Organophosphate

P

PEI	Pesticide exposure intensity
PNS	Periphery nervous system
PPE	Personal Protective Equipment
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-analysis

S

SD	Standard deviations
SDGs	Sustainable Development Goals
SPE	Solid phase extraction
SPSS	Statistical Package for Social Sciences Version

T

tDCVA	Trans-3-(2,2-dichlorovinyl)-2,2,dimethylcyclopropane carboxylic acid

U

USA	United States of America

W

WHO	World Health Organisation
3PBA	3-phenoxybenzoic acid
356TCP	3,5,6-trichloro-2-pyridinol

ABSTRACT

Introduction Agriculture remains an important sector in the Malaysian economy and pesticides are widely used in this sector. The use of pesticides poses a serious health threat to the population especially occupationally exposed populations. However, there is limited information on pesticide exposure and their health effects among farmers in Malaysia. Hence, the aims of this study were to assess pesticide exposure and investigate the health impact of pesticide use.

Methods A cohort study was conducted in Bachok and Kota Bharu districts, Kelantan state, east coast of Malaysia between September 2018 and February 2019. Information on demographics, general health, working practices and pesticide exposure was collected. A symptom diary was used to collect data on self-reported ill-health symptoms for seven days. The symptoms were categorised into pyrexial and respiratory factors based on previous published literature. Pesticide spraying was observed in order to complete the Dermal Exposure Assessment Method (DREAM) and pesticide exposure algorithms used to estimate exposure intensity scores based on Agricultural Health Study (AHS) and Ethiopian Farmer Study (EFS). Urine samples were collected in pre- and post-spraying and were analysed by using liquid chromatography-mass spectrometry. Associations between pesticide exposure and self-reported ill-health were examined.

Results 150 farmers growing either rice (n=83) or vegetables/fruits (n=67) participated. For farmers who reported using a specific pesticide, urine levels of the pesticide metabolite post-spraying were higher than pre-spraying levels for chlorpyrifos ($p < 0.01$), pyrethroids ($p < 0.01$) and cypermethrin ($p < 0.01$). All of the farmers who had minimal/low level of urinary metabolites used backpacker sprayers. Farmers who had high/very high level of urinary metabolites were exposed more on their head or face ($p=0.03$). The median EFS pesticide exposure intensity was higher for rice farmers compared to vegetable/fruit farmers ($p<0.01$).

32.7% of farmers reported on at least one occasion a health symptom occurring within 48hours after spraying in the spraying week. Symptoms were more common among the rice farmers ($p=0.04$) and the most common symptoms were feeling unusually tired which was reported by 16% of farmers, followed by feeling sweaty, shivery and feverish (13.3%) and having a headache (13%). 18.7% of the farmers were identified as having either a pyrexial factor occurring within 48 hours of spraying. The farmers who wore face shields had an increased risk of having the pyrexial factor (OR 2.9; 95% CI: 1.01, 8.71) and the farmers who wore chemically resistant boots had a reduced risk of having the pyrexial factor (OR 0.23; 95%CI: 0.08, 0.70).

The farmers who sprayed less than 1 day per week had 5-fold increased risk (OR=5.22; 95%CI: 1.69, 17.22) of having average/poor health and the farmers who had an incident while using pesticides had increased risk of having high blood pressure (OR=4.06;95%CI:1.21,11.66) and Parkinsonism/neurology symptoms. (OR=4.48; 95%CI: 1.46, 10.94), respectively.

Conclusions Farmers were exposed to pesticides in the spraying session based on assessment of urine metabolites, pesticide exposure intensity score and DREAM score parameters. Acute health symptoms were observed among the farmers following pesticide exposure. However, the symptoms were not specific to pesticide and might be due to other causes.The results collected in his study will provide baseline data on pesticide exposure and health effects in Malaysia.

DECLARATION

No portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning

COPYRIGHT STATEMENT

PRESENTATIONS AND PUBLICATIONS ARISING FROM THIS PHD STUDY

1. PUBLICATIONS

- Ahmad, Z. N. B. S., Brison, D & Povey, A. (2017). 0393 A Systematic Literature Review: Organophosphate (OP) pesticide exposure and semen quality (pp. A123–A124). BMJ. https://doi.org/10.1136/oemed-2017-104636.324
- Galea KS, Basinas I, Cherrie JW, Fuhrimann S, Harding AH, Jones K, et al. Impress: Improving exposure assessment methodologies for epidemiological studies on pesticides. Outlooks Pest Manag;30(1):18–9
- Jones K, Basinas I, Kromhout H, Van Tongeren M, Harding AH, Cherrie JW, et al. Improving exposure assessment methodologies for epidemiological studies on pesticides: Study protocol. JMIR Res Protoc;9(2).

2. ORAL PRESENTATIONS

- Zulkhairul Naim Bin Sidek Ahmad, Knowledge and Practice associated with pesticide use among farmers in Malaysia. Result from pilot study. The 7th Occupational and Environmental Exposure Science Meeting, Edinburgh, Scotland, 2nd April 2019
- Zulkhairul Naim Bin Sidek Ahmad. Exposure to pesticides and health effects on farm workers in East Coast of Malaysia. 3rd Annual Doctoral Academy Graduate Society (DAGS) Postgraduate Research (PGR) Conference, Whitworth Hall, Manchester, April 2019

3. POSTER PRESENTATIONS

- The 26th International Epidemiology in Occupational Health (EPICOH), Edinburgh, Scotland, 28th and 31st August 2017
- Zulkhairul Naim Bin Sidek Ahmad, A systematic Review: Organophosphate (OP) Pesticide exposure and semen quality. Fertility 2018, Liverpool, 4th-6th January 2018

ACKNOWLEDGEMENTS

NAIM

Nelson Mandela stated that It always seems impossible until it’s done. Finally, I did it. This PhD journey is like travelling in a foreign land where it involves exploring unknown places with unfamiliar cultures and people. The journey was so exhilarating, frightening, puzzling, exhausting and tedious. Nonetheless, considering twists and turns and unexpected obstacles, I survived this discovery. My PhD journey has taught me to be more resilient, persevering, never giving up and determined. This makes me perspire and occasionally drive me to the depths of despair. I believed that every path I took contributed to my new learning curve.

Aliya Ameena BZKN, the first daughter of mine. Thanks for your smile which gives me overwhelming joy. An enormous gratitude as always, to Aliya Ameena for your patient, waiting for me to come back every day from work.

I would like to thank my supervisor, Dr Andy Povey, his attentive eyes, meticulous editing and wealth of knowledge on the topic have made the most I could. He has also made my archival research both productive and enjoyable. Not to forget, my co-supervisors, Prof Dr Martie Von Tangeran and Prof Dr Daniel Brison for their advice, guidance, support and encouragement throughout this PhD study. This study would not be feasible without the assistance of the members of IMPRESS team. I would like to acknowledge Dr Kate Jones, Dr Laura Kenny, Dr Craig Sams at HSL for their support in the analysis of urine and assistance during my study time. I am also indebted to the farmers who have worked generously and have taken time to participate in this research and help make this study a success.

“ ***M****alaysia, oh tanah airku, tanah tumpah darahku, Negeri elok amat kucinta, Yang ku puja sepanjang masa* “. I’m coming home soon. I cannot wait to go back to my birthplace in serving my country and community. I promise myself that I will bring all the knowledge home and strive to make a difference.

Dedication

This research work is particularly dedicated to my family especially to my late father Sidek Ahmad BA, who always told me when I was a child;” You have a chance to be a doctor”. I wish you could be here to share this moment with me. Countless people have supported my efforts on this PhD journey.

To Neesa, Farrah, Kamil, Hidayah and all close friends, you have all made MY MANCHESTER and all of you deserve endless gratitude. Thank you for your valuable feedback, never ending support and unwavering encouragement. *“Aku puisikan namamu, didalam rindu, didalam sendu”.*

CHAPTER 1: INTRODUCTION AND LITERATURE REVIEW

1.1 INTRODUCTION

Environmental health problems are a global issue. In Malaysia, environmental health problems are mostly attributed to global warming or climate changes, air pollution, water pollution as well as environment chemicals including pesticides (1). In 2016, throughout the globe, approximately two million tons of pesticide was utilized. The top ten pesticide consuming countries in the world are China, the United State of America (USA), Brazil, Argentina, Canada, Ukraine, France, Malaysia, Australia and Spain. The top three highest countries for average annual pesticide use (kg/ha) were China (13.1 kg/ha), followed by Malaysia (8.1) and Brazil (6.0) (Table1.1) (2).

Table 1.1: Top ten countries that use pesticides worldwide

Country	Pesticide use	
	Tons	kg per hectare of cropland
China	1 763 000	13.1
USA	407 779	2.5
Brazil	377 176	6.0
Argentina	196 009	4.9
Canada	93 839	2.4
Ukraine	78 201	2.3
France	70 589	3.6
Malaysia	67 288	8.1
Australia	63 416	2.0
Spain	60 896	3.6

Adapted from (2)

In 2016, herbicides accounted for the most proportion of total pesticide use worldwide (47.5%), second were insecticides (29.5%) and followed by fungicides (17.5%) and other pesticides (5.5%) (3). It is estimated that by end of 2020, pesticide usage worldwide will increase up to 3.5 million tonnes (4).

As for year 2018, 11.0% of total employment in Malaysia was engaged in the agricultural sector and 24.0% of the total land in Malaysia was used for agricultural purposes. The agricultural system in Malaysia is undergoing progressive agricultural development from traditional to commercial systems (5). Due to this change, pesticides have been used widely in various farming practices such as vegetables, fruits, rice, rubber and palm oil plantations (6).

Worldwide, the health impacts of pesticide can greatly affect farming communities and have become one of the major public health problems (7). Many studies have been conducted and reported an association between pesticide exposure and acute (8–10) and chronic health hazards such as neurobehavioral changes (11–13), reproductive (14) and certain types of cancers (15,16). The health issues will subsequently result in economic losses due to increase medical expenses, decreased productivity and absence from work. It is a discouraging fact though that the scientific data available on pesticide use among occupationally exposed workers in Malaysia is limited. This contributes to the invisibility of this important public health issues.

1.2 DEFINITION AND CLASSIFICATION OF PESTICIDES

According to the Food and Agriculture Organisation of the United Nations, pesticides are defined as any chemical or biological substance that are mainly used in agriculture that are intended for preventing, destroying, repelling or mitigating any pests such as insects, mice and other animals, unwanted plants, fungi or microorganisms that will cause harm during the production, processing, storage, transport or marketing of food and wood to improve quality food and material through preservation, control of vector-borne diseases and crop protection (17).

Pesticides can be categorised based on their target organisms (e.g. rodenticides, insecticides, fungicides and herbicides), toxicity based on results of acute toxicity studies in the rat (e.g. extremely, highly, moderately or slightly hazardous and unlikely to present acute hazard) and their chemical families (e.g. organophosphates (OPs), organochlorines (OCs), carbamates and pyrethroids). The classification of certain type of pesticides remains difficult because one pesticide can belong to different chemical families and have different targets (18).

1.2.1 Classification based on the target organism

Pesticides have been classified based on the target organism due to the combination of compounds and a large number of chemical substances. The target organism includes all of the following; insecticides, fungicides, herbicides, rodenticides, miticides, nematicides and molluscicides (Table 1.2).

Insecticides are pesticides that kill inserts and commonly used in agriculture, medicine, and industry and have both household and commercial uses. Examples of insecticides include OCs, OPs, organosulfur, carbamates, formamidines, dinitrophenols, organotins, pyrethroids, nicotinoids, and pyrazoles (19).

Fungi can cause serious damage in agriculture resulting in crop loss and fungicides are used to treat fungal infection in animals. Examples of fungicides are hexaconazole, validamycin, benomyl, carbendazim and propiconazole (20).

Herbicides are pesticides that design to destroy and kill unwanted plant and can be classified in many ways. The most common classification is based on selectivity with selective herbicides being designed to kill certain types of plants usually grasses or leaf weeds while leaving the wanted crop relatively unharmed and non-selective herbicides which are designed to kill all plants. Examples of non-selective herbicides are paraquat and glyphosate and selective herbicides are chlorophenoxy acid and triazine which control board-leaf weeds (21).

Rodenticides are pesticides that kill rodents which include rats, mice, squirrels, woodchucks, chipmunks and other small animals. Examples of rodenticides include thallium, sodium monofluoroacetate, strychnine, zinc phosphide, yellow phosphorus, arsenic, alphanaphthyl thiourea (ANTU) and dichlorodiphenyltrichloroethane (DDT) (22).

Miticides are pesticides that kill mites. Examples of miticides include carbaryl, diazinon, dimethoate and fluvalinate (23). Nematicides are pesticides used to kill parasitic worms such as roundworms and threadworms and can be grouped into fumigant and non-fumigant ones based on their volatility in soil. Examples of fumigant nematicides are 1,3 dichloropropene, chloropicrin, dimethyl disulphide and allyl isothiocyanate and non-fumigant nematicides are oxamyl, fluensulfone and fluazaindolizine (24). Molluscides are pesticides used to kill molluscs such as octopi, squid, snails and slugs. Examples of molluscides are alkyldimethylbenzylammonium, dimethylbenzyl ammonium chloride and niclosamide (25).

Table 1.2: Definition based on the target of organism

Target organism	Definition
Insecticides	Chemical or biological agent formulated to kill, harm, repel or mitigate one or more species of inserts
Fungicides	Substance or preparation used to kill fungi or fungal spores
Herbicides	Chemical used to destroy and kill unwanted plants.
Rodenticides	Chemical design to kill rodents such as rat, mice, squirrels, woodchucks, chipmunks and other small animals.
Miticides	Chemical used to kill mites
Nematicides	Chemical used to kill plant-parasitic nematodes
Molluscicides	Chemical which kills mollusc

Adapted from (19-25)

1.2.2 Classification based on the nature of toxicity

The World Health Organisation (WHO) proposed a classification of pesticides according to their potential hazard and this was approved by the 28th World Health Assembly in 1975 (26). This classification is based on oral and derma5l toxicity to the rat based on estimating the median lethal dose (LD50) that produces death in 50% of the rats. The classification is based on five categories ranging from unlikely to present acute hazard (Class U) to extremely dangerous (Class Ia) (Table 1.3). This classification is accepted worldwide following extensive international consultation. Around the world, about 400 class Ib active substances are on the market. In industrial countries, most of WHO class I pesticides are not allowed or strictly prohibited for use because of their toxic effects by which a teaspoonful (5 ml) of these pesticides would be enough to kill a human (27).

Table 1.3: WHO Classification of pesticides based on the nature of toxicity

WHO Class	Toxic effect	LD50 for the rat (mg/kg body weight)	
		Oral	Dermal
Ia	Extremely hazardous	<5	<50
Ib	Highly hazardous	5-50	50-200
II	Moderately hazardous	50-2000	200-2000
III	Slightly hazardous	Over 2000	Over 2000
U	Unlikely to present acute hazard	5000 or higher	

Adapted from (26)

1.2.3 Classification based on chemical structure

The most common way of classifying pesticides is based on chemical structure (Table 1.4) with four common groups being OPs, OCs, carbamates and pyrethroids (18).

Table 1.4: Four common pesticide groups, their mode of action and examples of pesticides

Chemical group	Mode of action	Example	WHO Classification
OPs	Inhibition of acetylcholinesterase (AChE) enzyme resulting in overstimulation of nicotinic and muscarinic receptors and the central nervous systems.	Chlorpyrifos Glyphosate Malathion Methyl- parathion Parathion	II III III Ia Ia
OCs	Inhibition of chloride flows into the nerve by binding at gamma-Aminobutyric acid (GABA) chlorine ionophore complex.	Aldrin DDT Dieldrin	II II II
Carbamates	Similar to OPs but the inhibitory effect on cholinesterase is short duration	Aldicarb Carbofuran Carbaryl	Ia Ib II
Pyrethroids	Act on the sodium and chloride channels in nerve and muscle cells and lead to hyperexcitability followed by paralysis.	Allethrin Bifenthrin Cyfluthrin Permethrin Resmethrin	II II Ib II III

Adapted from (28)

OP compounds are ester, amide or thiol derivatives of phosphoric, phosphonic or phosphinic acids. The general structure of OPs shown in Figure 1.1. The R^1 and R^2

groups are usually a methyl or ethyl group, O is either a sulphur or oxygen atom bound to the phosphorus with a double bond and OR^3 represents the leaving group that is displaced when the OP phosphorylates AChE and is the most sensitive to hydrolysis (29). OP pesticides affect the nervous systems, which is primarily attributed to binding to AChE. AChE is an important neurotransmitter at neural and neuromuscular junctions and degrades acetylcholine into choline and acetic acid. This will inhibit AChE function and can lead to a disruption of nerve impulses leading to the irreversible accumulation of excess acetylcholine at nerve synaptic and neuromuscular junctions and overstimulation of muscarinic and nicotinic receptors (30).

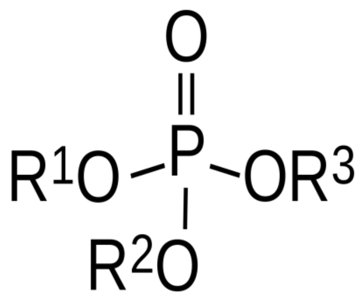


Figure 1.1: General chemical structure of OPs compound

Adapted from (29)

An OC is a chlorinated hydrocarbon containing at least one covalently bonded chlorine atom and they have been extensively used in agriculture and for mosquito control from the 1940s to 1960s (31). Compare to OPs, OCs are more stable and remain in the environment for a longer time and accumulate in human and animal fatty tissues (18). OCs prevent the deactivation or closing of sodium/ potassium gates of the axon resulting in a hyper excitability state (19). Two principal groups of OCs are the DDT and the chlorinated alicyclic compounds which include aldrin, dieldrin, endrin, heptachlor, chlordane and endosulfan (31). The general structure of DDT is shown in Figure 1.2

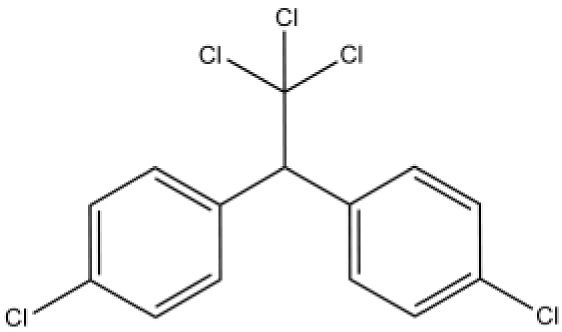


Figure 1.2: General chemical structure of DDT, OC compound

Adapted from (31)

A carbamate pesticide is an organic compound derived from carbamic acid. The general structure of carbamates is shown in Figure 1.3. R^1 is an alcohol, oxime or phenol and R^2 and R^3 are either hydrogen or a methyl group. The mode of action of carbamates is similar to that of OPs in that they inhibit AChE enzymes, but the bond formed is reversible and brief (32).

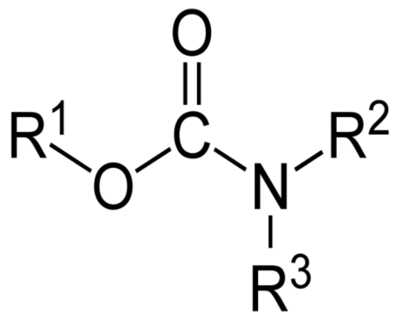


Figure 1.3: General chemical structure of carbamate compound

Adapted from (32)

A pyrethroid is a synthetic version of pyrethrin that shares some similarity to the natural pesticide pyrethrum, which is produced by chrysanthemum flowers (33). The general structure of the pyrethroid is shown in Figure 1.4. Pyrethroids can be classified into two groups; (a) type I pyrethroids that have a basic cyclopropane carboxylic ester structure (e.g. permethrin), and (b) type II pyrethroids that have an alpha-cyano group (e.g. cypermethrin and deltamethrin).

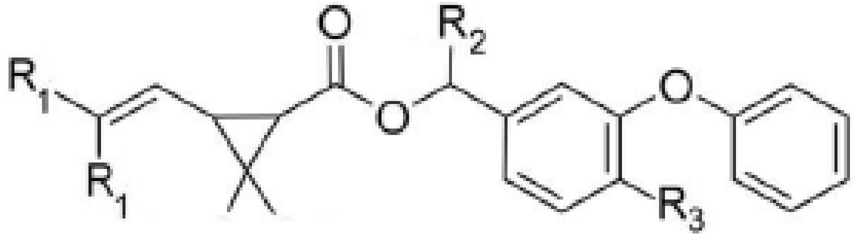


Figure 1.4: General chemical structure of pyrethroid compound

Adapted from (33)

1.3 AGRICULTURAL SYSTEMS AND PESTICIDE USE IN MALAYSIA

Malaysia is in Southeast Asia and the total population is approximately 33 million with a total area of 330,000 of square kilometres. Figure 1.5 shows a map of Malaysia, which consists of the Malay Penisula and East Malaysia. The Malay Peninsula is also known as West Malaysia and has land borders with Thailand and Singapore. Its area is around 132,000 square kilometres, which is nearly 40% of Malaysia or slightly larger than England. East Malaysia has land borders with Indonesia and Brunei. The total area is around 200,000 square kilometres which represents approximately 60.0% of the total land of Malaysia.

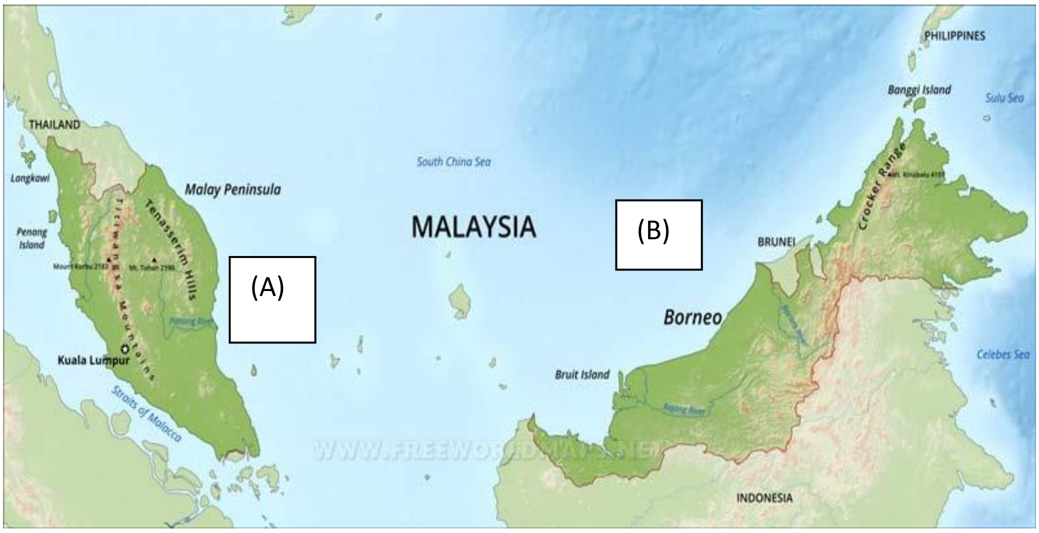


Figure 1.5: Map of Malaysia
(A) Malay Penisula or West Malaysia, and (B) East Malaysia

Adapted from (34)

Its main contributor to the economy is the service sector, followed by manufacturing, mining and agricultural sectors (35). Despite providing a small contribution, agriculture remains a backbone and important sector of Malaysia's economy. Agriculture in Malaysia is controlled by the Ministry of Agriculture and Agro-based Industry and can be divided into three subsectors include; (i) Agro-industry which is for export market which comprises of oil palm, rubber and cocoa, (ii) Food industry for domestic consumption including fruits, rice and vegetables, and (iii) Miscellaneous group which serves both domestic consumption and export including pepper, coconuts, sweet potato, etc (36,37).

The agricultural sector is crucial in the national economy of Malaysia. It contributed 8.2% or RM96 billion to the Gross Domestic Product (GDP) in 2017. Oil palm was a major contribution to the GDP of agriculture sector at 46.6% followed by other agriculture (18.6%), livestock (11.4%), fishing (10.5%), rubber (7.3%) and forestry (5.6%) (38). Among the agro-food commodities, paddy is cultivated over approximately 394,200 hectares in 2020, followed by fruits and coconut, which accounted for 203,100 hectares and 85,800 hectares, respectively (39) (Table 1.5).

Table 1.5: Land usages by agro-food commodities (2010-2020)

Type of Agrofood	Land usage (acre)		
	2010	2015	2020
Paddy	444,300	394,200	368,200
Fruits	239,400	203,100	206,900
Coconut	105,700	85,800	77,600
Vegetables	39,300	38,400	45,700
Others	7,100	9,600	10,200

Adapt from (39)

The number employed in the agriculture sector was 1,631, 600 in 2017, a gain of 21.7 thousand (1.3%) from the previous year and this sector was dominated by men (77.2%). It provides major employment especially in rural areas (38).

Pesticides are commonly used in agriculture and their use is critically important to improve productivity, protection of crop losses, vector disease control as well as the quality of food (40). During the past few decades, there has been widespread use of pesticides in Malaysia and other developing countries. Malaysia pesticide use has steadily increased since 2006 and as for 2016, pesticide use accounted for nearly 50,000 tonnes of active ingredients with total use of 5.9kg/ha of crop land (Figure 1.6) (41). In 2015, herbicides were the most imported pesticide use which accounted for 64% total pesticides, followed by insecticides (26%), fungicides (6%) and rodenticides (4%) (42).

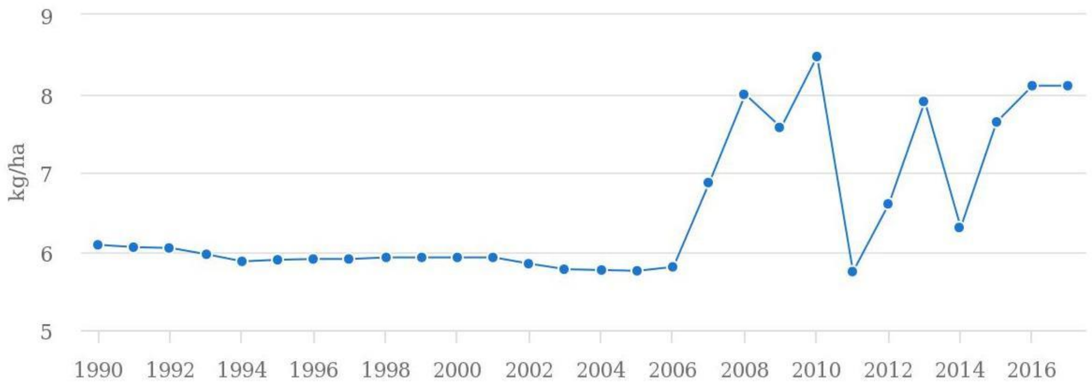


Figure 1.6: Average pesticide uses per area of cropland in Malaysia.

Adapted from (41)

Malaysian farmers apply pesticides all year-round due to multiple cropping and do not undertake seasonal spraying like in the UK, the USA and other Northern countries. However, the frequency of spraying changes depending on the weather. During the rainy season, the frequency of spraying is higher than that in dry weather due to quicker washing off the pesticides. In addition, the farmers often apply pesticides according to their pesticide spraying schedule even though there may be no sign of a pest outbreak. The farmers have a lot of different crops which require the use of different pesticides which can also lead to more spraying. Both this more frequent spraying and spraying on different crops could lead to extended exposure and pesticide load in body (43,44).

1.4 ROUTES OF PESTICIDE EXPOSURE

There are many pathways of exposure to pesticides. The three most common routes for pesticides exposure are dermal absorption, oral ingestion and inhalation.

1.4.1 Dermal absorption exposure

The most common pathway of occupational pesticide exposure is via dermal absorption (45,46). There are three types of pesticide dermal interactions which produce systemic effects or a combination of local and systemic effects. Firstly, the pesticide acts locally and induce local effects such as irritation or degradation of the skin barrier. Secondly, the pesticide may pass through the skin and produce to the systemic effects such as to the endocrine system. Lastly, the pesticide triggers a complex immune system which subsequently produces allergic skin reactions at the point of contact or at skin sites remote to the contact (47).

This might happen as results from splashes and spills on protective clothing or unprotected skin especially during tank mixing, loading or applying (48). The dermal exposure level varies depending on different parts of the body. A study conducted in China during pesticide spraying showed that the lower part of the body such as thigh and lower leg were the most exposed body part compared to the upper body part (49).

The contamination of the body also depends on the type of activity. During downward pesticide spraying, 50-85% of the total estimate dermal exposure was through legs and 10-25% was through hands. However, during up and sideward pesticide spraying, 65% of the total estimate dermal exposure was through the upper body and 25% was through legs (50). During mixing, hand contribute half of the dermal contamination follow by forearm (13.0%), legs (12.3%) and head (10.8%) (51).

The transport of pesticide particles to the body surface occurs through three main routes which are emission, deposition and transfer. Emission is the direct release of the substance onto the skin or clothes (e.g. splashing, the immersion of hands into a liquid or powder (diameter of > 100microm, spilling while fixing nozzle or nose, etc). The deposition is the settlement of the contaminant mass of small particles with an aerodynamic diameter of <100 micrograms such as vapours or mist onto the skin or clothing after their first release into the air and environmental factors such as meteorological conditions (e.g. walking into the spray cloud because of the spraying against the wind). The transfer involves the transport of mass from the contaminated surface onto skin or clothing. For example, skin contact with surfaces such as worktables, floor, working tools and equipment that got contaminated with agent in previous applications or the present one (52).

1.4.2 Inhalation exposure

In agriculture settings, inhalation exposure contributes a small fraction of the total exposure and appears to be more limited than dermal exposure. This is likely due to low vapour pressures of many pesticides (45,51,53). During mixing and loading of liquid pesticides in closed mixing systems, the inhalation of pesticide is little and gives no effects. However, the inhalation route becomes more significant when a person is working in poorly ventilated or in confined spaces, breathing vapours, dust or mists (54).

The hazards from vapours and very small particles pose more serious risks compared to bigger particles. When low-pressure equipment such as hydraulic sprayer is used, the hazard is reasonably low because the droplets are too large to remain in the air. However, in high pressure from ultra-low volume equipment or fogging equipment, the droplets are smaller and the droplets can be carried in the air for sometimes and increase the potential hazards to cause respiratory symptoms (55,56).

1.4.3 Ingestion exposure

For the general population, ingestion exposure is more common route of exposure. Among occupationally exposed workers, oral exposure of pesticides is a less common route of pesticide absorption, but it may result in serious injury. Ingestion of pesticides can also occur accidentally by drinking, but it is more likely to occur unintentionally when farmers have not washed their hands and while eating or smoking. Accidental oral exposure can also arise when the label of the pesticides has been removed from the original bottle. It has been reported that the major site of absorption is in the small intestine whereby pesticides are absorbed into the bloodstream and distributed to the entire body (54). In Tanzania, more than half of the accidents involving pesticides happen among children compared to occupationally exposed workers and are more common in girls (57).

1.5 EXPOSURE ASSESSMENT OF PESTICIDE

1.5.1 Determinants of pesticide exposure

There are many factors that may influence the determinants of pesticide exposure. The pesticide exposure on workers depends on the type of applicant equipment used. The farmers who applied pesticide by themselves had significantly higher pesticide exposure than farmers who had the pesticide applied by a commercial applicator (58). Comparing between air blast and hand spray, air blast was associated with a four to five-fold increase of pesticide exposure compared to hand spray (59). In a bigger farm, rear-mounted devices are associated with higher exposure than trailer sprayers (60). In addition, pesticides applied using high-pressure motor machines is associated with a higher degree of exposure than the backpacker sprayer (61,62).

The pesticide has various types of formulations such as solid, liquid or gas and different types of formulations even though same active ingredient have different capabilities to penetrate to the body and produce the exposure. For example, Aurelie et al. found that bentazon, which is one type of herbicide showed the difference in rate in permeability in two difference formulations (liquid and powder diluted in water). Hence, the exposure produce was difference (63).

As discussed in the previous section, there are three routes of pesticide entry and liquid or gas can get into the body through all routes. Therefore, liquid or gas formulations tend to have higher chance to enter the body and are more hazardous than solid. Also, a liquid formulation is prone to splashing or spillage, resulting in direct contact with skin if no cloth protection or indirect contact from contaminated clothes (64). Whereas solid formulations have a lower chance to penetrate through inhalation. However, small solid particles can remain long enough on the skin and also may penetrate the body similar to liquid or gas (48).

The duration and frequency affect exposure to the pesticide. The farmers who handle pesticide once a year had lower exposure than those who apply in consecutive days or weeks and the farmer who used pesticides for than 20 years had higher exposure than those farmers who used pesticides less than 20 years (64,65).

Pesticide related work tasks during pesticide use also have an impact on exposure. Generally, pesticide user involves in the following activities; (a) mixing and loading, (b) application, and (c) equipment cleaning (3). Risks of workers exposure to pesticide are higher during the mixing and loading phase because the pesticides product is handed and high exposure events such as spills can occur but it may vary between the workers (48,60,66). However, the risk of pesticide exposure while applying pesticide may exceed mixing and loading because of longer task duration (51).

Personal Protective Equipment (PPE) is referring to clothing and devices worn to protect head, hand, back, eye, face, foot and skin from contact with pesticide or pesticide residues (67). Use of proper PPE has been considered important for the safety of the workers and can significantly reduce pesticide exposure either though dermal, inhalation or oral exposure (51,59). It also has been found that many of the farmers who used the PPE were healthy compared to those farmers who did not use the PPE (68). Hence, PPE is required during pesticides handling and application (67).

The farmers are also exposed to pesticides when doing activities that are not directly related to pesticide use. For example, repairing and cleaning the spraying equipment were found to influence pesticide exposure (59). This is due to spills and splashes of pesticide residual in the spraying equipment and direct contact to the spraying equipment due to faulty or missing protective equipment (54).

Hygiene practices also appear to be important factors associated with pesticide exposure (69). Washing hands right away after pesticide use may reduce the exposure because pesticides are either absorbed through or absorbed to the skin on the hands. Together, changing clothes immediately after exposure may also reduce exposure (70,71).

1.5.2 Exposure assessment method

Exposure can be defined as events in which the person is in contact with an environmental stressor such as biological, chemical, behavioural or physical factor (72). Exposure assessment provides a method to evaluate exposure (in this study is related to pesticides) to human body and environment through identifying potential sources and routes of exposure. These methods of assessment can be used to support decisions on risk management. To date, there a variety of methods have been used in epidemiological studies and can be broadly divided into direct and indirect exposure assessment. Example for direct exposure assessment method includes biological monitoring using blood, urine or skin and personal sampling for exposure assessment of inhalation and dermal. Examples of indirect exposure assessment method include self-reported exposures, job title, and job histories by questionnaires. Data from indirect exposure assessment method can be used to develop semi-quantitative methods such as pesticide exposure intensity algorithms, job-exposure matrices, and dermal exposure assessment (73).

A systematic review of articles on occupational exposure to pesticides, conducted by Ohlander et al. showed that indirect methods were more commonly used than direct methods especially in retrospective cohort studies and case-control studies. Self-reported exposure and job exposure matrices were the main indirect methods used and were increasing in trend and use of expert assessments and job title assessment were decreasing. However, the use of pesticide exposure intensity as determined by algorithms and predictive models showed no changes. For direct exposure assessment method, biomonitoring particularly blood sample was the most commonly used and accounted for every tenth exposure assessment method occurrence and was common in cross-sectional and prospective cohort studies (73).

1.5.2.1 Biological monitoring of pesticide exposure

Biological monitoring of exposure to pesticides includes measuring enzyme activities in blood and levels of parent pesticides or their metabolites in blood and urine. This are considered the most accurate indicators of recently absorbed dose of pesticides

(74). Table 1.6 shows examples biological monitoring methods to measure exposure to pesticides.

The advantages of measuring biomarkers include incorporation of exposure from all routes and this will give an overall measure of exposure. The biomarkers can be used as an indicator of exposure to estimate the internal dose especially in low doses or complex mixtures of compounds exposure. Thus, it is considered a gold standard for assessing exposure to pesticides (74).

A blood sample is used to measurement of cholinesterase enzyme activities including AChE in red blood cell and butyrylcholinesterase (BChE) in plasma (75). Depression of plasma AChE activity in blood indicates exposure to OPs. Many studies have measured AChE among populations occupationally exposed to pesticides

Table 1.6: Type of biological sample and example of metabolites

Type of pesticide	Biological sample	Example of metabolites/enzyme
OPs		
All ChE inhibitors	Blood	AChE
Alkyl phosphates	Urine	3 dimethyl phosphate biomarkers; a) dimethylphosphate (DMP) b) dimethylthiophospahte (DMTP) c) dimethyldithiophosptate (DMDTP) 3 diethyl phosphate biomarkers; a) diethylphosphate(DEP) b) diethylthiophosphate (DETP) c) diethyldithiophosphate (DEDTP)
Chlorpyrifos	Urine	3,5,6-trichloro-2-pyridinol (356TCP)
Glyphosate	Urine	Glyphosate
Carbamates		
All ChE inhibitors	Blood	AChE
Carbofuron	Urine	3-hydroxy carbofuran
Pyrethroids		
Cypermethrin	Urine	Trans-3-(2,2-dichlorovinyl)-2,2,dimethylcyclopropane carboxylic acid (tDCVA),cis-3-(2,2-dichlorovinyl)-2,2,dimethylcyclopropane carboxylic acid (cDCVA)
Deltamethrin	Urine	Deltametrin
Permethrin	Urine	Permethrin

Adapted from (76)(77)

(78–80). For blood AChE, the baseline activity needs to be taken after at least 30 days free from exposure to OPs. It needs to be taken at least twice with a minimum of three days but not more than 14 days interval between samples. A third sample will be taken if two tests differ more than 20%. The baseline level is calculated based on an average of samples. To be clinically significant, the post-exposure sample needs to be 15-20% lower than the baseline level (80,81).

The limitation of using AChE is to require repeated blood taking, which is invasive to have pre-exposure (baseline activity) and also post-exposure to OPs. This is difficult if the farmers continuously exposed to pesticides without any break to allow washout of OP (82). Exposure to OPs is normally measured in urine by quantifying dialkylphosphate metabolites (DAPs). Once OPs pesticide exposure occurs, they can be metabolised and can produce up to six DAPs which include three dimethyl phosphate biomarkers; DMP, DMTP and DMDTP and three diethyl phosphate biomarkers; DEP, DETP and DEDTP (Figure 1.7).

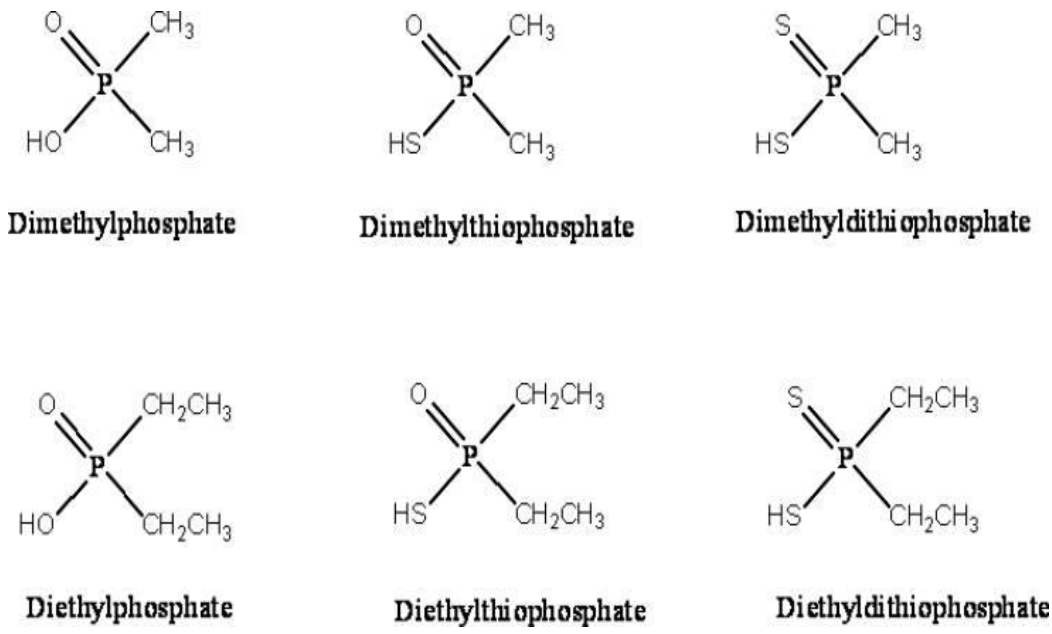


Figure 1.7: Structures of DAP metabolites of OPs

Adapted from (83)

Not all OPs produce the same spectrum of DAP metabolites. Table 1.7 shows examples of OPs and their potential metabolites. Many studies have used urine DAP to measure exposure to pesticides (84–88). Alkyl phosphates are excreted in the urine in a short period (6-24 hours) after the exposure. So, samples need to be collected at the end of the exposure (89). Table 1.7 shows the examples of DAP in urine.

Table 1.7: Examples of DAP in urine

Metabolite	OP
DMP	Dichlorvos, methylchlorpyrifos, trichlorfon, methylparathion
DEP	Diazinon, parathion, demeton, chlorpyrifos
DMTP	Azinphos-methyl, fenitrothion
DMTP	Diazinon, parathion, chlorpyrifos

Adapted from (74)

Glyphosate is not metabolised in the human body and excreted unchanged, predominantly in urine and thus the compound can be measured in urine. The half-life of glyphosate is between 5.5 to 7 hours (90,91). Many studies have been conducted to evaluate glyphosate exposure among those occupationally exposed by measuring urinary glyphosate levels (91–94).

356TCP is a metabolite of chlorpyrifos and excreted mainly via urination (Figure 1.8). Hence, it can be measured in urine (95). The half-life of 356TCP is 27 hours following exposure, and 90% excretion of total dose occurs 24-48 hours after dermal exposure (96). Many studies conducted to evaluate exposure to chlorpyrifos by

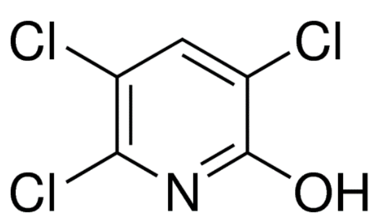


Figure 1.8: Chemical structure of 356TCP, which is the main degradation product of chlorpyrifos

Adapted from (96)

using urinary 356TCP. Urinary 356TCP has therefore been widely used as a biomarker for assessing exposure to chlorpyrifos among the general or occupationally exposed population (97–102).

Pyrethroids are extensively metabolised to form less lipophilic compounds, which are rapidly and easily excreted in the urine. 3-phenoxybenzoic acid (3PBA) is commonly used to assess exposure for seven pyrethroids (i.e. cypermethrin, deltamethrin, cyhalothrin, esfenvalerate, fenpropathrin, permethrin and tralomethrin) in urine (Figure 1.9) (103). The half-life of 3PBA is 2.5-12 hours, and elimination is nearly completed within 5 days of exposure (104).

Other metabolites such as tDCVA and cDCVA that derive from parent compounds of cypermethrin were also measured. The half-life of the metabolites in the body is 12.3 hours and peak between 12 and 36 hours (105). Many studies used urine pyrethroids to assess pesticide exposure among occupational exposed population (97,106,107).

The use of biomarkers has limitations as it is not possible to measure all pesticide metabolites at the moment especially in developing countries. Furthermore, they are not able to capture past exposure. Hence, it more suitable for prospective cohort or cross-sectional studies. Besides, it also costly to do laboratory testing and unsuitable for more extensive epidemiology studies (104).

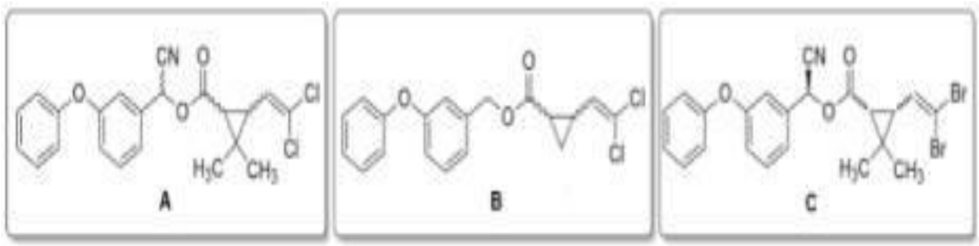


Figure 1.9 Chemical structure of pyrethroid compound;
(A) Permethrin, (B) Deltamethrin, and (C) alpha-cypermethrin

Adapted from (105)

1.5.2.2 Self-reported exposures by questionnaire

Self-reported exposure is determined by using a questionnaire. One of the advantages of self-reported exposures is that it is easy and relatively quick to obtain information on exposure, particularly in studies of a retrospective nature. The data generally collected from self-reported methods includes as information on exposure to specific pesticide active ingredients, job-exposure matrices and PPE use (69). Many studies used this method to assess exposure (69,108–111). However, self-reported methods can be prone to recall bias, which is a potential source of misclassification among exposed and unexposed. Also, reliability of self- reported exposure needs to be assessed by using Intraclass correlation, Kappa and Cronbach Alpha. For interpretation for ICC or Kappa; (a) above 0.90 (excellent), (b) between 0.89 and 0.75 (good), (c) between 0.74 and 0.50 (moderate), and (d) below 0.49 (poor). For interpretation for Cronbach Alpha; (a) above 0.90 (excellent), (b) between 0.89 and 0.8 (good), (c) between 0.79 and 0.7 (acceptable), (d) between 0.69 and 0.6 (questionable), (e) between 0.59 and 0.5 (poor), and (f) below 0.49 (unacceptable) (112).

1.5.2.3 Semi-quantitative methods to assess pesticide exposure by using Pesticide Exposure Intensity (PEI) algorithm

Algorithms have been designed to estimate pesticide exposure intensity. Pesticide exposure intensity (PEI) is a semi-quantitative method to assess pesticide exposure by using self-reported information from the questionnaire or observational checklist on type of pesticides used and pesticide exposure such as working practices, use of PPE and post work hygiene.

Dosemeci et al. have developed a PEI model based on the Agricultural Health Study (AHS) in the USA. This was a cohort study conducted among more than 58,000 pesticide applicators in North Carolina and Iowa. This study aimed to evaluate long-term chemical-specific pesticide exposure based on two algorithms (general and detailed algorithm). Information was collected on enrolment and from take home questionnaires (113). In this cohort study, two algorithms were developed (general and detailed) chemical-specific information chemical specific 2-4 d, chlorpyrifos. This study utilizes a mixture of professional judgment and the existing literature data to quantify potential pesticide exposure in a more detailed manner than has been attempted before. This algorithm has been validated particularly with the post-application urinary concentration of pesticide (114–116).

Negatu et al. has developed an easily semi-quantitative exposure assessment based on the PEI algorithm for a developing country, Ethiopia. This was conducted in the central eastern part of Ethiopian among a group of 256 pesticide applicators and 345 re-entry workers from the different farming systems (small scale irrigated, large scale greenhouses, and large scale open). This study aimed to assess daily, annual, and cumulative lifetime exposure of pesticide among applicators and re-entry workers. Two specific semi-quantitative exposure algorithms for pesticides applicators and re-entry workers were developed. This study concluded that the algorithm could help evaluate health effects associated with pesticide exposure, particularly in low and middle-income countries where resources are limited (117).

1.5.2.4 Dermal exposure assessment

Dermal exposure is the main route of pesticide exposure among the occupationally exposed population. Hence, dermal exposure assessment is a crucial aspect of risk assessment as it may lead to the development and improvement of

There are various indirect methods to assess human dermal exposure, such as Control of Substances Hazardous to Health (COSHH) (118), Dermal Exposure Ranking Method (DERM) (119), Dermal Exposure Assessment Method (DREAM) (120) and Estimation and Assessment of Substance (EASE) (121). However, DREAM was chosen because it is based on a validated conceptual model for dermal exposure, applicable for a broad range of agents, providing reliability and accuracies of semi-quantitative estimates of dermal exposure (52,120,122,123). DREAM is an observational structured semi-quantitative method to assess dermal exposure for chemical or biological agents (120). DREAM consists of an inventory and evaluation part. The Inventory part consists of five questionnaire sections, which includes

Table 1.8: Summaries of two establish PEI

Parameter	Dosemeci et al. (113)	Negatu et al. (117)
Name of study, year	Agriculture Health Study (AHS), 2001	Ethiopian Farmer Study (EFS), 2016
Country	USA	Ethiopia
Population	58,000 pesticide applicators in North Carolina and Iowa	601 farm workers (256 pesticide applicators and 345 re-entry workers) employed in 3 different farming systems (small scale, large scale greenhouse, large scale open)
Method	Questionnaire - Time and intensity related information on pesticide exposure such as mixing, duration and frequency, application methods and PPP use - Take home questionnaire to obtained information maintenance or repair of mixing and application equipment, work practice and personal hygiene	Questionnaire - Pesticide exposure-related factors (job title, application methods, mixing, the presence of indoor application, cleaning of equipment, total amount of pesticides used in kilogram and litter (kg +1) of pesticide used per day, number of working days per year and duration of employment. - PPE use and hygienic behaviour related factor (replacement of PPE, washing, and bathing after pesticide-related work)
Aim of the algorithm	To estimate the specific intensity of exposure score to individual pesticides	To adapt the semi-quantitative exposure assessment method from AHS to characterise exposure to a pesticide in applicators and re-entry farmers and farmworkers
Algorithm	Two algorithms were developed 1) <u>General exposure algorithm</u> The variables consist of mixing status, application method, repair equipment status, and PPE use 2) <u>Detailed exposure algorithm</u>	Two algorithms were developed 1) <u>Applicator exposure algorithm</u> The variables consist of application method, farm layout (open or closed), pesticide mixing condition, cleaning spraying equipment, the intensity of pesticide application per day, PPE use, personal hygiene, annual frequency and duration of employment. 2) <u>Re-entry exposure algorithm</u>

	Consist of variables from the general algorithm and additional variables such as type of mixing system (enclosed or open), tractor with enclosed cab, frequency of washing equipment, frequency of replacing old gloves, personal hygiene and changing clothes after the spill	The variables consist of PPE use, personal hygienic behaviour, annual frequency behaviour, the annual frequency of re-entry work and duration of employment
Algorithm equation	General algorithm intensity level = (Mix+ Appl + Repair) X PPE Detailed algorithm intensity level = [(Mix x Enclosed) + (Appl x Cab) + Repair + Wash] X PPE X Repl X Hyg X Spill Definition Mixing = Mixing status Appli = Application method Repair = Repair equipment status PPE = Personal protective equipment use Enclosed = Using enclosed mixing system Cab = Tractor with enclosed cab and/or charcoal filter Wash = Status of washing pesticide equipment after application Repl = Replacement old gloves Hyg = Personal hygiene Spill = Changing clothes after a spill	Cumulative applicator = [(Appli method X Appli type) + (Mix X Enclosed) + Wash] X (Amount pesticide used per application/applicator) X (PPE X Repl) X (Hyg) X (Appli days per year) X (Durat) Definition Appli method= Application method Appli type = Either indoor /outdoor application Mixing = Mixing status Enclosed = Using enclosed mixing system Wash = Cleaning of spraying equipment PPE = Use PPE Repl = Replacement of PPE Hyg = Hygienic measures Appli days per year = Application days per year Durat = Duration of employment
Weight factors	Based on published pesticide exposure literature and professional judgment	Based on published literature or based on expert judgements and modifications were made provided the different farming system in Ethiopia

Advantages	1) The algorithm is based on updated algorithm that has been revised based on two exposure monitoring studies 2) The weighting factors for the revised algorithm now incorporates exposure measurements taken of Agricultural Health Study (AHS) participants for the application methods and their reported use of personal protective equipment (PPE) 3) Based on an extensive review of the world's literature and the use of the Pesticide Handlers Exposure Database (PHED) which included many different chemicals 4) Suitable for large scale cohort studies 5) Useful for looking at chronic and single exposures	1) Two specific semi-quantitative exposure algorithms for pesticides applicators and re-entry workers were developed. 2) Suitable for three distinctly different farming systems [small-scale irrigated, large-scale greenhouses (LSGH), and large-scale open (LSO)]
Disadvantages	1) The algorithm is based on America style of farming	1) There is no biomonitoring validation

Table 1.9: Information obtained in the inventory part

Section	Data obtained on
Department	Information about the observer and general questions on department such as main activity and cleaning activities
Agent	Characteristics of chemical agent which include the concentration of an active ingredient, physical state, boiling temperature, viscosity and stickiness
Job title	Number of workers with this job title and hygiene behaviour questions such as cloths hygiene, hand hygiene, and shower behaviour
Task	Information about task done such as duration, frequency and number of workers
Dermal exposure	Potential and actual exposure based on information from emission, transfer, and deposition of agent

Adapted from (120)

department, agent, job title, task and dermal exposure. The questionnaire is completed by the person who observes the task (Table 1.9) (120).

The evaluation part is based on variables from the inventory part and 33 variables are included to estimate potential exposure and actual dermal exposure for nine different body parts which include head, upper arms, lower arms, hands, torso front, torso back, lower body part, lower legs and feet. Each answer in both parts coincides with a pre-assigned value such as 0, 0.3,1,3 and 10 that is further put into the algorithm and resulting in a semi-quantitative estimation of pesticide exposure. The total DREAM score is divided into six categories from very low (0-9.9 DU), low (10-29.99 DU), moderate exposure (30.99-99.99 DU), high (100-299.99 DU), very high (300-999.99 DU) and extremely high exposure (>1000 DU) (120).

Potential dermal exposure (Skin-$P_{TASK.BP}$) is the amount of exposure on clothing and uncovered skin that is estimated based on the sum of nine body parts in three different exposure routes; emission (E_{BP}), deposition (D_{BP}) and transfer (T_{BP}) (Equation 1.1).

Eq.1.1: Skin-$P_{TASK.BP}$ = 9 body parts (E_{BP} + D_{BP} + T_{BP})

The exposure route estimates are the product of multiplying probability (P), intensity of each route (I), estimates of intrinsic emission properties of the substance (E_I), and exposure route factor for each body part (ER) (Equation 1.2).

Eq.1.2.1: $E_{BP} = P_{BP}.\ I_{BP}.\ E_I.\ ER_E$

Eq.1.2.2: $D_{BP} = P_{BP}.\ I_{BP}.\ E_I.\ ER_D$

Eq.1.2.3: $T_{BP} = P_{BP}.\ I_{BP}.\ E_I.\ ER_T$

Probability (P) is a frequency of agent transport on clothing and uncovered skin and can be divided into; (i) unlikely (< 1% of task duration), (ii) occasionally (1-10% of task duration), (iii) repeatedly (10-50% of task duration), and (iv) almost constantly (>50% of task duration). Intensity (I) is the amount of agent transport on clothing and uncovered skin and can be divided into; (i) small amount (<10% of the body part), (ii) medium amount (10-50% of the body part), and (iii) large amount (>50% of the body part).

The ER weight due to emission (ER_E) is 3 and that due to deposition (ER_D) and transfer (ER_T) is 1. Intrinsic emission (E_I) is calculated based on the multiplying of physical state (PS) of substance concentration (C), formulation (F), dustiness (DU), stickiness (SS), evaporation (EV), and viscosity (V). Solid, liquid and vapour have different formulation (Equation 1.3).

Eq.1.3.1: $E_{I(SOLID)} = PS.\ C.\ F.\ DU.\ SS$

Eq.1.3.2: $E_{I(LIQUID)} = PS.\ C.\ EV$

Eq.1.3.3: $E_{I(VAPOUR)} = PS.\ C$

Actual dermal exposure (Skin-$A_{TASK.BP}$) is the amount of exposure on skin calculated by multiplying potential exposure (Skin-$P_{TASK.BP}$) with the protection factor for nine body parts. The protection factor of the other eight body part (O_{BP}) is calculating based on multiplying a factor representing material covering skin (M), protecting factor of clothing materials (PFM_{BP}) and replacement frequency of clothing (RF) (Equation 1.4).

Eq.1.4: $O_{BP} = M.PFM_{BP}.RF$

The material (M) is divided into; (i) woven, (ii) non-woven, and (iii) non-permeable, and replacement frequency (RF) is divided into used (i) once, (ii) daily,

(iii) weekly, and (iv) monthly, respectively. The protection factor of clothing materials for other body parts (PFM_{BP}) is 0.3. Meanwhile, the protection factor of hand (O_{HA}) is calculated similarly to O_{BP} with additional factors for glove connecting well to the clothing or arms (GC), percentage of task duration that gloves are being worn (GD), the second pair of gloves under outer-gloves (UG) with replacement frequency (URF) and use of barrier cream (BC) (Equation 1.5).

Eq.1.5: $O_{HA} = M.PFM_{HA}.RF.GC.GD.UG.URF.BC$

The M and RF are similar to O_{BP} and for GC, UG, and BC, the answer either yes or no. The percentage of GD is divided into; (i) 0-25% of task duration, (ii) 25-99 of task duration, and (iii) 100% of task duration, and URF is divided into; (i) daily, (ii) weekly, and (iii) monthly.

1.6 HEALTH EFFECTS OF PESTICIDES ON HUMAN HEALTH

The use of pesticides has given many benefits such as increased agricultural yields and protection of the harvests. At the same time, pesticide application can also result in adverse health effects on the workers and impact on the environment of the surrounding area (124). According to the WHO, there are at least three million incidents of pesticide poisoning worldwide and about 30000 people are killed (7). Although a policy for banned certain highly toxic was implement in Malaysia starting from 2006, pesticide poisoning incidents still reported in an average incidence rate of 3.8 per 100 000 populations and increasing in trend (125).

Health effects of pesticides may be classified as acute or chronic based on the period it takes for symptoms of toxicity to develop. However, this study is more focused on acute health effects.

1.6.1 Acute health effects of pesticide exposure

The acute health effect of a pesticide sometimes calls acute pesticide poisoning (APP) refers to its ability to cause harmful effects or illness by any route of entry from suspected or confirmed exposure within 48 hours (126). Clinical presentation due to pesticide exposure can vary significantly due to a broad range of pesticides and toxicities. This includes respiratory, cardiovascular, gastrointestinal, neurotoxic, nephrotoxic, ocular and dermal. In general, the symptoms from acute pesticide exposure can be divided into three main groups which are mild, moderate, and severe (127). Table 1.10 shows the symptoms that might indicate pesticide poisoning.

The symptoms of pesticide exposure depend on the mode of action of every pesticide. OPs are among the pesticides that documented associated with acute health effects (128). Acute exposure to OPs causes inhibition of AChE in the brain, neuromuscular junction and peripheral nerves. This is characterised by central nervous system (CNS) effects and muscarinic and nicotinic effects in the periphery nervous system (PNS). The toxic effects of OPs are associated mainly with short-term exposures to high concentrations of pesticide during the manufacture, formulation, mixing and application of these chemicals. In these cases, death may occur from respiratory failure due to the paralysis of respiratory muscles, increased bronchial secretions and depression of the respiratory centre in the brain.

Table 1.10: General symptoms that might indicate pesticide poisoning

Mild symptoms	Moderate symptoms	Severe symptoms
Any of the following • Irritation of the nose and throat • Loss of appetite • Nausea • Diarrhea • Headache • Dizziness • Change in mood • Insomnia • Weakness or fatigue • Restlessness • Nervousness • Increased thirst • Irritation of the eyes • Irritation of the skin • Excessive sweating	Any of the mild symptoms, plus any of the following • Excessive salivation • Coughing • Sore throat • Palpitation • Trembling • Vomiting • Abdominal cramps • Muscular incoordination • Mental confusion • Blurring of vision	Any of the mild or moderate symptoms, plus any of the following • Inability to breathe • Extra mucous in the airways • Increase breathing rate • Unconsciousness • Death • Small or pinpoint pupils

Adapted from (127)

1.6.1.1 Acute symptoms reported by the farmers in developing countries and also Malaysia following pesticide exposure

Many studies have been conducted in developing countries about acute health problems and pesticide exposure. Thus, a systematic review was undertaken to gather the published evidence on acute symptoms following pesticide exposure in developing countries.

1.6.1.2 Search Strategy, inclusion and exclusion criteria for identification of studies

This review was reported in accordance with the 2009 Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines (129). The search strategic for this review combined electronic searched and hand searching. For electronic search, a review of papers published between 2010 and 2020 was carried out by using PubMeb. For hand searching, cross-referencing of review papers and research were also screened manually to identify further potentially relevant citations. The following medical subject headings (MeSH) and keywords were used; "acute" AND "Pesticide OR fungicide OR insecticide OR rodenticide" AND "health" AND and "poisoning". The inclusion criteria considered for further review included; (a) the population of interest was occupationally exposed, (b) the outcome was acute health effects or acute pesticide poisoning, (c) studies published in English, (d) all type of observational studies, (e) studies conducted in developing countries, and (f) only full text articles. The excluded studies including; (a) a conference abstract, (b) chapters of a book, and (c) in vitro and animal studies. The main author did the search and screened all the titles and abstract and retrieved the full text of any articles. Then, the full articles were reviewed.

1.6.1.3 Quality assessment and data collection and analysis

The methodological quality assessment of each study was assessed by the Newcastle Ottawa Scale (NOS). This NOS was chosen because it is an easy and convenient tool to use for quality assessment of non-randomised studies. According to the NOS scale, the star system was used to assess the quality of a study in three domains; (a) selection of participants (maximum 5 stars), (b) comparability (maximum 2 stars), and (c) outcome (maximum 3 stars). The maximum star was 10 and the evidence was classified based on four categories; (a) very good (9-10 points), (b) good (7-8 points),

(c) satisfactory (5-6 points), and (d) unsatisfactory (0-4 points) (130). The articles were summarised using the following information author, country of the study and year of publication, sample size, population, type of pesticide, exposure and outcome measure and findings.

1.6.1.4 Results

The PRISMA flow chart (Figure 1.10) depicts the number of published articles and theses screened at each stage into the review. The search of PubMed identified 1205 records with 1186 articles remaining after the removal of duplicates. Of these, 1134 articles were excluded after screening the titles and then abstract because these studies did not meet the selection criteria. Out of 52 retrieved articles, 36 studies were excluded after full text review because they were did not have a relevant study population and health outcome (n=21) and were conducted in developed countries (n=15). Thus, 16 studies were identified as eligible to be included in this review.

Table 1.11 provides details about the quality of nonrandomized studies based on the NOS. The methodological quality of study designs was satisfactory to good overall. Only four studies justified and calculated the sample size. None of the studies ascertained exposure by using more reliable methods to assess the exposure. All of the studies clearly provided non-respondents and statistical test to analyse the data.

Of the 16 published papers, all the identified studies were cross-sectional in nature and five studies used a comparative cross-sectional study design, where the farmers who exposed to pesticide compared with unexposed group, which not exposed to pesticide. The population of included studies were largely from farming areas. Most of the included studies were conducted in Asia; Malaysia (n=5) (44,62,131–133), Nepal (n=2) (10,134), Thailand (n=2) (8,9), Bangladesh (n=1) (135), Cambodia (n=1) (109) and China (n=1) (136), South America; Argentina (n=1) (137), Caribbean; Dominican Republic (n=1) (138) and Africa, Tanzania (n=1) (139) and Palestine (n=1) (140). Six studies had a sample size less than 100 (8,44,109,133,135,138) and the sample size for the remaining studies were between 101 to 999

(9,10,62,131,134,136,137,139,140) except in one study where the sample size was more than 1000 (132).

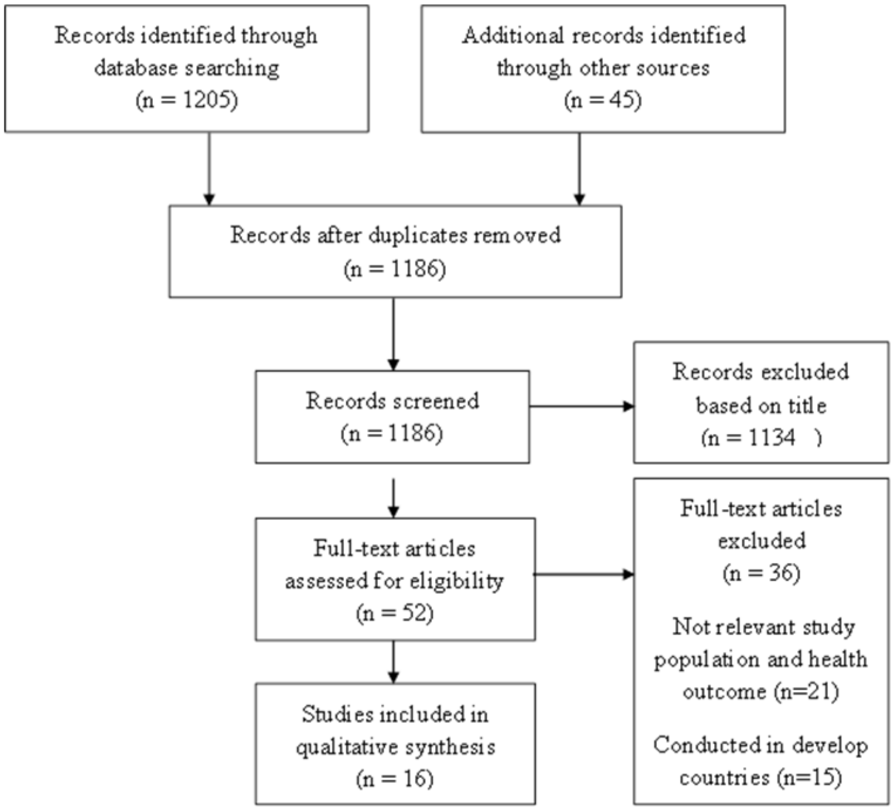


Figure 1.10: PRISMA flowchart of included studies

Table 1.12 shows a summary of 16 studies that investigated acute health effects and pesticide exposure. The details of these studies were extracted into six primary elements, which included; (a) author, (b) country and year, (c) study design and sample size, (d) study population, (e) type of pesticide, (f) outcome measure, (g) type of exposure, and (h) exposure measure. All of the studies used a self-reported questionnaire and with a focus on general acute pesticide poisoning symptoms as an outcome except for one study which focussed on respiratory (44) and neurology symptoms (139). Four studies reported the number of symptoms as being less than 10 (131–133,137), eight studies reported number of symptoms between 10 to 30 (8–10,62,109,140) and one study reported 66 symptoms (136). One study did not mention the number of symptoms (135). There were no studies that used actual clinical diagnoses based on hospital records or from doctors. The majority of the studies did not specify types of pesticides except three studies that focused on insecticides and herbicides (8,44,132). This systematic review found methodological variations across the type of exposure assessment. Nine studies measured the exposure by using a self-reported questionnaire only (109,131,132,134–138,140). Three of these studies collected data on exposure through self-reported questionnaire and blood AChE levels (9,10,139) and four remaining studies used either self-reported questionnaire and personal air monitoring (n=1) (44), self-reported questionnaire, blood AChE and personal sampling by using wipe sample for OPs (n=1) (8) or self-reported followed questionnaire and buccal cell (n=1) (133) or DREAM questionnaire, personal air sampling and liver enzyme levels (n=1) (62). Nine of the studies used past exposure, where the pesticide exposure from previous spraying event (10,109,131,132,134,135,137,138,140) and seven studies used more recent exposure, where the pesticide exposure from current spraying event (8,9,44,62,133,136,139).

The study outcome which includes the prevalence of acute health symptoms and associations between acute health and pesticide exposure for each study are summarized in Table 1.13. It should be noted that few studies provided details on the definition of acute symptoms and how they classified to have acute symptoms. Five studies reported the overall prevalence of acute health effect (8,109,131,134,136). The range prevalence of acute health symptoms was between 8.8% to 88.0%. Among five comparative studies, the most common symptom among farmers who exposed to pesticide were numbness which reported in three studies and the prevalence ranging from 41.2% to 59.0% (9,62,133), eye irritation (reported in three studies) with the prevalence range from 29.1% to 43.6% (9,62,133) and excessive tiredness (reported in two studies) with the prevalence of 52.2% and 76.0% (10)(138). The most common symptoms among unexposed group were headache with prevalence between 33.3% and 78.0% (8,133,138), sleep disturbance with prevalence of 21.4% and 58.0% (62,138) and numbness with prevalence between 38.5% and 45.7% which reported in two studies (9)(62). One study reported neurology symptoms only in two groups of farmers (139).

Among studies which reported among farmers who exposed to pesticide, the most common neurological symptoms among flower farmers were excessive sweating (46.4%), body weakness (34.5%) and abnormal tiredness (28.6%) and the most common neurological symptoms among onion farmers were body weakness (91.1%), body pain (64.3%) and headache (58.9%) (139). One study reported respiratory symptoms only where the most common symptoms were cough (41.0%), phlegm (39.8%) and wheezing (18.1%) (44). Among those non comparative studies, the most common symptoms were headache (reported in seven studies) with the range of prevalence between 18.0% to 55.1% (8,132,134,135,137,139,140), followed by skin irritation (reported in three studies) with the range of prevalence between 11.6% to 62.0% (136,137,140) and dizziness (reported on three studies) with the range of prevalence between 27.8% to 80.7% (8,131,134).

Four studies did not report an association in their studies which include two comparative studies (132,134,135,139). All of the comparative studies who report an association showed an association between pesticide exposure and health symptoms. Three out of four studies reported the level of AChE was lower in farmers who exposed to pesticide (n=2) (8,9) and self-reported health symptoms (n=1) (10). One study that used bucall cell shows that the frequency of cytogenetic damage was found significantly higher among farmers as compared to unexposed.

1.6.1.5 Discussion

This systematic review revealed that the prevalence of acute symptom following pesticide exposure varied between studies and ranged from 50%-80%. The definition of APP is an essential aspect of health-related outcomes. The criteria used by different studies to diagnose APP were widely heterogeneous. Thus, the prevalence of APP varies between studies and might be over or underestimated. It should be noted that few studies provided details on the definition of acute symptoms and how the authors classified to have acute symptoms. Therefore, to minimize heterogeneity, it is recommended to restrict the definition by only using classification based on WHO guidelines which is any illness or health effects resulting from suspected or confirmed exposure to pesticide within 48 hours (126). This is to ensure consistency among the studies.

Table 1.11: The NOS for assessing the quality of nonrandomised studies

Author	Selection (Maximum 5 stars)				Comparability (Maximum 2 stars)	Outcome (Maximum 3 stars)		Total
	Representiveness of the sample	Sample size	Ascertainment of exposure	Non-respondents	Outcome measure	Assessment of outcome	Statistical analysis	
Hutter et al (138)	*			*	**	*	*	7
Mwabulambo et al (139)	*			*	**	**	*	7
Khan et al (131)	*	*		*	**	*	*	7
Hamsan et al (44)	*	*		*	**	*	*	7
Ali et al (132)	*	*		*	*	*	*	6
Nganchamung et al (8)	*			*	**	**	*	7
Hamid et al (133)	*			*	**	**	*	7
Sumon et al (135)	*				**	*	*	5
Gayatri et al (134)	*			*	*	*	*	5
Butinof et al (137)	*			*	*	*	*	5
Sapbamrer et al (9)	*			*	**	**	*	7
Neupane et al (10)	*	*		*	**	**	*	8
Zhang et al (136)	*			*	**	**	*	7
Jensen et al (109)	*			*	**	*	*	6
Zyoud et al (140)	*			*	**	*	*	6
Baharuddin et al (62)	*			*	**	**	*	7

Table 1.12: Studies on acute health effects and pesticide exposure in developing countries

Author	Country, year	Study design, sample size	Study population	Type of pesticide	Outcome measure	Type of exposure	Exposure measure
Hutter et al (138)	Dominican Republic, 2018	A comparative cross-sectional study, 38 exposed and 33 unexposed	Exposed – Farmers who used pesticide Unexposed - The organic farmers	General pesticide	Self-reported outcome (Questionnaire) 19 health symptoms	Past exposure	Self-reported exposure (Questionnaire)
Mwabulambo et al (139)	Tanzania, 2018	Cross-sectional study, 140 farmers (84 flower farmers and 56 onion farmers)	Farmers	General pesticide	Self-reported outcome (Questionnaire) 16 neurological symptoms	More recent exposure	Self-reported exposure (Questionnaire) and blood AChE
Khan et al (131)	Malaysia, 2018	Cross-sectional study, 270 palm oil workers	Palm oil workers	General pesticide	Self-reported outcome (Questionnaire) 8 health symptoms	Past exposure	Self-reported exposure (Questionnaire)
Hamsan et al (44)	Malaysia, 2018	Cross-sectional study, 83 farmers	Farmers	13 type of pesticides (azoxystrobin, buprofezin, chlorantraniliprole, difenoconazole, fipronil, imidacloprid, isoprothiolane, pretilachlor, propiconazole, pymetrozine, tebuconazole, tricyclazole and trifloxystrobin)	Self-reported outcome (Questionnaire) 7 respiratory symptoms	More recent exposure	Self-reported exposure (Questionnaire) and personal air sampling
Ali et al (132)	Malaysia, 2018	Cross-sectional study, 1040 farmers	Farmers	Aminsta 505 and Karate	Self-reported outcome (Questionnaire) 3 health symptoms	Past exposure	Self-reported exposure (Questionnaire)
Nganchamung et al (8)	Thailand, 2017	Cross-sectional study, 90 farmers	Farmers	Organophosphate	Self-reported outcome (Questionnaire) 20 health symptoms	More recent exposure	Self-reported exposure (Questionnaire), blood AChE and hand wipe sample for organophosphate

Hamid et al (133)	Malaysia, 2016	A comparative cross-sectional study, 39 exposed and 30 unexposed	Exposed - Farmers who exposed to pesticide Unexposed - Staff at the research centre who not exposed to pesticide	General pesticide	Self-reported outcome (Questionnaire) 8 health symptoms	More recent exposure	Self-reported exposure (Questionnaire) and buccal cell epithelium to check for cytogenetic damage
Sumon et al (135)	Bangladesh, 2016,	Cross-sectional study, 30 farmers	Farmers	General pesticide	Self-reported outcome (Questionnaire) Health symptoms (Not mention how many)	Past exposure	Self-reported exposure (Questionnaire)
Gayatri et al (134)	Nepal, 2014	Cross-sectional study, 125 farmers	Farmers	General pesticide	Self-reported outcome (Questionnaire) 12 health symptoms	Past exposure	Self-reported exposure (Questionnaire)
Butinof et al (137)	Argentina, 2015	Cross-sectional study, 837 farmers	Farmers	General pesticide	Self-reported outcome (Questionnaire) 8 health symptoms	Past exposure	Self-reported exposure (Questionnaire)
Sapbamrer et al (9)	Thailand, 2014	A comparative cross-sectional survey, 182 exposed and 122 unexposed	Exposed – Farmers who occupational exposed to pesticide Unexposed – The general population who non occupationally exposed	General pesticide	Self-reported outcome (Questionnaire) 19 health symptoms	More recent exposure	Self-reported exposure (Questionnaire) and blood AChE
Neupane et al (10)	Nepal, 2014	A comparative cross-sectional study, 90 exposed and 90 unexposed	Exposed - Vegetable farmers who used pesticide Unexposed - Blood donors	General pesticide	Self-reported outcome (Questionnaire) 17 health symptoms	Past exposure	Self-reported exposure (Questionnaire) and blood AChE

Zhang et al (136)	China, 2011	Cross-sectional study, 910 farmers	Farmers	General pesticide	Self-reported outcome (Questionnaire) 66 health symptoms and grouped into seven groups such as general symptoms, skin, nervous system, gastrointestinal tract, respiratory system, eyes and cardiovascular system	More recent exposure	Self-reported exposure (Questionnaire)
Jensen et al (109)	Cambodia, 2010	Cross-sectional study, 89 farmers	Farmers	General pesticide	Self-reported outcome (Questionnaire) 27 health symptoms	Past exposure	Self-reported exposure (Questionnaire)
Zyoud et al (140)	Palestine, 2010	Cross-sectional study, 381 farmers	Farmers	General pesticide	Self-reported outcome (Questionnaire) 15 health symptoms	Past exposure	Self-reported exposure (Questionnaire)
Baharuddin et al (62)	Malaysia, 2010	A comparative cross-sectional study, 140 exposed and 80 unexposed	Exposed – Farmers who exposed to pesticide Unexposed – Office workers who not exposed to pesticide	2,4-D and paraquat	Self-reported outcome (Questionnaire) 13 health symptoms	More recent exposure	DREAM questionnaire, personal air sampling and liver enzyme

Among the included studies, various health outcomes were identified including respiratory, neurology, dermatology, eye, gastrointestinal, cardiovascular systems. The most common symptoms were headache (reported in 8 studies), followed by skin rashes (n=6) and dizziness (n=5). From this comparative analysis, it was found that the self-reported questionnaire was the main exposure assessment method used (reported in fifteen studies) followed by biological monitoring such as blood AChE activity (reported in four studies), buccal cell epithelium to measure cytogenetic damage (reported in one study) and liver enzyme to measure potential liver disease (reported in one study), semi-quantitate measurement (DREAM questionnaire) (reported in one study) and personal sampling by using wipe sample for OPs (reported in two studies). The diversity in the symptoms and method used for measuring the exposure makes it difficult to compare the association across studies. Hence, crude comparison needs to be use by comparing groups based upon subjective (ie questionnaire) and more objective forms of exposure assessment (ie biological monitoring).

Most of the significant findings were not adjusted for potential confounders. All of the studies used self-reported questionnaire to obtain information on health outcomes. The use of questionnaires is prone to information or misclassification bias due to under or over reporting of health symptoms. Publication bias is also possible which the authors more interested to published papers with positive results concealed the papers with negative results.

This review has several strengths. This review builds from validated systematic methodology and has relied on recently published articles (last 10 years). This study only focussed on developing countries where this study is going to be conducted. The study population in developing countries might be different from those in developed countries such as South Korea, Japan, UK or USA and also they may not necessary follow the same practice as in developed countries. Additionally, this study focused specifically on occupationally exposed populations.

Despite its several strengths, this review had several limitations as well. The limitation of this systematic review is to have used only PubMed as a database for

Table 1.13: The prevalence of acute health symptoms and associations between acute health and pesticide exposure across studies

Author	Study outcome	
	Prevalence	Associations
Hutter et al (138)	The most common symptoms among farmers who exposed to pesticide were runny nose (78%), headache (77%) and strong tiredness (76%) The most common symptoms among unexposed group were headache (78%), sleeplessness (58%) and runny nose (52%)	The symptoms such as dizziness, excessive salivation, excessive tiredness, stomachache, irregular heartbeat, skin rashes (all p<0.01), difficulty in breathing (p<0.02), runny nose (p<0.05) and watering eyes (p<0.05) were significantly more common in farmers who exposed to pesticide than unexposed group.
Mwabulambo et al (139)	The most common neurological symptoms among flower farmers were excessive sweating (46.4%), body weakness (34.5%) and abnormal tiredness (28.6%) The most common neurological symptoms among onion farmers were body weakness (91.1%), body pain (64.3%) and headache (58.9%)	There were no significant associations between all self-reported symptoms and level of AChE among farmers
Khan et al (131)	The prevalence with mild symptoms was 64.4%, the moderate symptom was 35.6% and nobody had severe symptoms The most common symptoms among farmers who exposed to pesticide were diarrhoea (97.4%), vomiting (90%), and dizziness (80.7%)	The severity of symptoms was associated with lesser income, lower education, shorter duration of spraying, untrained worker and non-use of PPE (all p value <0.01)
Hamsan et al (44)	The most common respiratory symptoms among farmers who exposed to pesticide were cough (41%), phlegm (39.8%) and wheezing (18.1%)	There was a significant association between isoprothiolane and chest pain (p=0.02) However, no other significant association between pesticide exposure and respiratory symptom
Ali et al (132)	Among those farmers who reported having headache, 59.6% used karate and 28.2% used Aminsta 505 Among those farmers who reported having body weakness, 33.7% used karate and Aminsta 505	

	Among those farmers who reported having sleepy, 28.4% used karate and 71.4% used Aminsta 505 No prevalence data was reported	
Nganchamung et al (8)	The prevalence of acute health symptoms among farmers who exposed to pesticide during 48 hours after applying pesticide was 50% The most common symptoms among farmers who exposed to pesticide were headache (31.1%), dizziness (27.8%) and fatigue and body weakness (22.8%)	AChE was inversely associated with dizziness ($p<0.01$), headache ($p<0.01$), fatigue ($p<0.01$), skin itchiness ($p<0.01$), nausea and vomiting ($p<0.01$), skin rashes ($p=0.03$) and cough ($p=0.04$)
Hamid et al. (133)	The most common symptoms among farmers who exposed to pesticide were numbness (59%), blurring of vision (56.4%), and eye irritation (43.6%) The most common symptoms among unexposed were headache (33.3%), blurring of vision (33.3%), and eye irritation (23.3%)	The frequency of cytogenetic damage was found significantly higher ($p<0.01$) among farmers as compared to control
Sumon et al (135)	The most common symptoms following pesticide exposure among farmers were vomiting (51%), headache (18%), and eye irritation (12%)	
Gayatri et al (134)	The prevalence of acute symptoms among farmers who exposed to pesticide was 67.2% The most common symptoms among farmers who exposed to pesticide were skin irritation (62%), headache (55%) and respiratory difficulties (29.6%)	
Butinof et al (137)	The most common symptoms following pesticide exposure were skin irritation (47.4%), headache (40.4%) and easily fatigue (35.5%)	Marital status, length of time in the job, incomplete PPE use, combines the use of pesticide, and application of the insecticide were significantly associated with symptoms
Sapbamrer et al (9)	The most common symptoms among farmers who exposed to pesticide were eye irritation (42.9%), anxiety (42.9%) and numbness (41.2%) The most common symptoms among unexposed were numbness (38.5%), anxiety (36.9%), and eye irritation (33.6%)	Farmers had a significantly lower median AChE activity than controls ($p=0.03$) The prevalence of difficulty in breathing and chest pain was significantly higher in farmers than in control ($p <0.01$ and $p <0.05$, respectively)

Neupane et al (10)	The most common symptoms among farmers who exposed to pesticide were blurred vision (55.6%). extreme tiredness (52.2%) and excessive sweating (47.7%) The most common symptoms among exposed were excessive tiredness (22.2%), excessive sweating (18.9%), and skin allergic (18.9%)	The acute health symptoms were significantly more common in farmers who exposed to pesticide than unexposed group. The level of blood AChE was significantly lower among farmers who exposed to pesticide than control ($p<0.01$). The factors associated with acute symptoms were toxic pesticides, poor PPE use, and poor hygiene practices
Zhang et al (136)	The prevalence of acute pesticide poisoning among farmers who exposed to pesticide was 8.8% The most common symptoms among farmers who exposed to pesticide were dermal (11.6%) and nervous system (10.7%).	There were associations between acute symptoms and use of PPE ($p=0.01$), equipment leakage ($p<0.01$), safety knowledge ($p<0.01$) and work when sick ($p<0.01$)
Jensen et al (109)	The prevalence of acute symptoms among farmers who exposed to pesticide was 88% The most common symptoms among farmers who exposed to pesticide were dry throat (68.5%), dizziness (57.3%) and headache (55.1%)	The acute health symptoms were associated with duration of spraying ($p<0.01$), education level ($p=0.03$) and PPE use ($p<0.05$)
Zyoud et al (140)	The most common symptoms among farmers who exposed to pesticide were skin rash (37.5%), headache (37%) and excessive sweating (24.9%)	There was a negative association between self-reported symptoms and use of PPE ($p <0.01$)
Baharuddin et al (62)	The most common symptoms among farmers who exposed to pesticide were numbness (50.7%), sleep disturbance (30.5%) and eye itchiness (29.1%) The most common symptoms among unexposed were numbness (45.7%), sleep disturbance (21.4%), and reddish face (15.9%)	The liver enzyme (ALT and GGT) in the exposed group was higher than on the control group ($p<0.05$) The reported symptoms such as nausea, excessive sweating, imprecise movement, numbness (all $p<0.01$), reddish face ($p=0.01$) and skin itchiness ($p=0.03$) were significantly more common in farmers who exposed to pesticide than unexposed group.

bibliographic research. Meta-analysis was not possible due to heterogeneity across results of studies of the descriptions such as sampling criteria, study design and assessment of outcome and exposure. Two studies were omitted because the full paper could not be obtained. If it were able to assess full paper, this will provide additional value to the overall review.

The majority of the reviewed studies used a cross-sectional study design. Hence, it provides insufficient evidence to infer a causal relationship of pesticide exposure with acute health effects. The reviewed studies were also limited by small sample size. This may give a weaker association and loses power to detect the associations.

1.6.1.6 Conclusion

In conclusion, this review provides that the symptoms of acute health problems due to pesticides were diverse. Besides, it involved multiple systems, rarely pathognomonic and can resemble conjunctivitis, dermatitis, respiratory infection and also gastrointestinal illness. Hence, the findings should be interpreted with caution. This finding provides new insights on the importance of investigating the associations between pesticide exposure and occupationally exposed populations. Further detailed work is needed to better characterise these associations and high-quality studies such as cohort studies are needed to substantiate to what extent pesticide exposure can lead to acute health problems.

1.7 RESEARCH AIMS AND OBJECTIVES

The overall aims for this study were to assess the exposure of pesticides and investigate the potential effects of pesticides on the acute ill-health on the farmers in Malaysia. In keeping with the aims, the general objectives of this study were:

a) To describe the demographic, working practices during previous spraying sessions and pesticide exposure among the farmers and determinants of this exposure

b) To determine the knowledge and practice of pesticide use among the farmers and determinants of the knowledge and practice of pesticide use

c) To determine the associations of PPE use and demographics and working practices and pesticide exposure

d) To investigate the nature of ill-health and its associations with demographic factors, working practices and pesticide exposure among farmers

e) To investigate the nature and determinants of acute health symptoms reported among farmers following pesticide spraying

1.8 THESIS STRUCTURE

This thesis was organised into eight chapters consisting of the following key components;

Chapter 1: Introduction and literature review

It begins with an introduction to the definition and classification of pesticides. This is followed by a description of the agriculture system and pesticide use in Malaysia. Routes of pesticide exposure, exposure assessment of pesticide, which includes determinants and method to assess pesticide exposure, are also discussed. Next, the acute health effects of pesticides on human health are also discussed. Finally, aims and objectives and thesis structure are presented.

Chapter 2: Methods for pilot and main study

This chapter describes the methods used during the pilot and main study, outlining the study design, location and participants. This is followed by ethical approval, study recruitment and study participations and details about the data collection instruments, statistical analysis, as well as sample size calculation. The chapter ended with an operational definition of variables.

Chapter 3: Exposure to pesticides and health effects among farmers in two areas in Malaysia- A pilot study

This chapter will discuss the feasibility of conducting this study in Malaysia. This chapter describes the results of the pilot study and how well the study protocol worked for the pilot study and identified modifications needed for use in the main study.

Chapter 4: Demographic, working practices, pesticide exposure and health status of farmers- The main study

This chapter describes the demographic, working practices during the previous spraying week, pesticide use during the first day of the current spraying week among farmers in Kelantan state, Malaysia. This is followed by the data on general health, somatic and screen positive neuropsychiatric symptoms. This chapter also include the exposure assessment methods used on this study which include pesticide exposure intensity algorithm, DREAM questionnaire and urine metabolites. This is followed by association between pesticide exposure and associated factors. This chapter ended with data on general health, somatic and screen positive neuropsychiatric symptoms and its associated factors.

Chapter 5: Knowledge and practice of pesticide use among farmers and associated factor for knowledge, practice and PPE use

This chapter discusses the knowledge and practice of pesticide use and associated factors. Besides, the associations for PPE use among farmers will be presented.

Chapter 6: Self-reported acute health symptoms during a week following spraying

This chapter will present data self-reported acute health symptoms during a week of current spraying week and its associated factors.

Chapter 7: Overall discussion

This chapter concludes the entire thesis with overall discussions based on specific objectives. This will allow a deeper understating on the overall discussion of this PhD thesis. This is followed by the recommendations of future research.

CHAPTER 2: METHODS FOR PILOT AND MAIN STUDY

2.1 INTRODUCTION

This chapter discusses the methods used for both the pilot and main study in order to achieve objectives of this study. This discussion includes study design, population and location, study recruitment and participation, data collection instruments, statistical analysis, sample size and case definition of variables. The differences in methods used between the pilot and main study are also clearly outlined. Flow charts are included to provide a clear summary of the material provided.

2.2 STUDY DESIGN, POPULATION AND LOCATION

2.2.1 Study design for pilot and main study

The pilot and main study had a prospective cohort study design to investigate health effects especially acute health potentially arising from exposure to pesticides in a population of farmers.

The participants of this pilot and main study were male farmers who were (i) 18 years or older, and (ii) planned to use pesticides during the spraying session. Men were excluded if they (i) had a known medical condition which could be the cause of infertility (e.g. genetic conditions such as cystic fibrosis, chromosome abnormalities), (ii) if they had ever undergone treatment that could be a cause of infertility (e.g. chemotherapy), or (iii) knew that they had already a specific problem such as azoospermia.

2.2.2 Pilot study population and location

The pilot study was conducted in two areas in Malaysia; namely Ranau, in Sabah State and Bachok, in Kelantan State (Figure 2.1). In Ranau it was conducted in Kundasang sub district and in Bachok the Tawang sub district.

Ranau is located in the interior of Sabah State in the eastern part of Malaysia on the island of Borneo (Figure 2.1). This district is situated approximately 4000 km from Kuala Lumpur, the capital city of Malaysia and approximately 110 km from Kota Kinabalu, the capital of Sabah. The total area is 2978 square kilometres and the population is nearly 100,000 people and is an almost entirely Dusun ethnic community. The main source of income is from agriculture for 50.0% of the working population followed by government service and tourism, for 13.0% and 7.0%, respectively (141).

Meanwhile, Bachok is a district of Kelantan State on the east coast of the Malaysian mainland (Figure 2.1). This district is situated approximately 600 km from Kuala Lumpur. The district covers a total area of 264.5 square kilometres. It has a population of about 189,000 people and more than 90.0% are Malay. The communities of this area are primarily engaged in agricultural activities as well as business, fishing and working in government and private sectors (142).

2.2.3 Main study population and location

The main study was recruited from Bachok and Kota Bahru district, in Kelantan State (Figure 2.2). It was conducted in eight sub-districts of Bachok; namely (a) Tawang (b) Perupok (c) Tanjung Pauh (d) Bekelam (e) Melawi (f) Mahligai (g) Gunung, (h) Melawi and three sub-districts of Kota Bahru; namely (i) Kedondong, (j) Chenok, (k) Melor. Both districts contain large agricultural areas with mainly vegetable and fruit farming.

Kota Bharu district is the capital city of Kelantan State. The district is situated approximately from 450 km Kuala Lumpur and has a total area of 120 square kilometres. The total population is nearly 315,000 people and more than 90.0% are Malay. The communities are mainly engaged in business and also working in the government and private sectors (143).

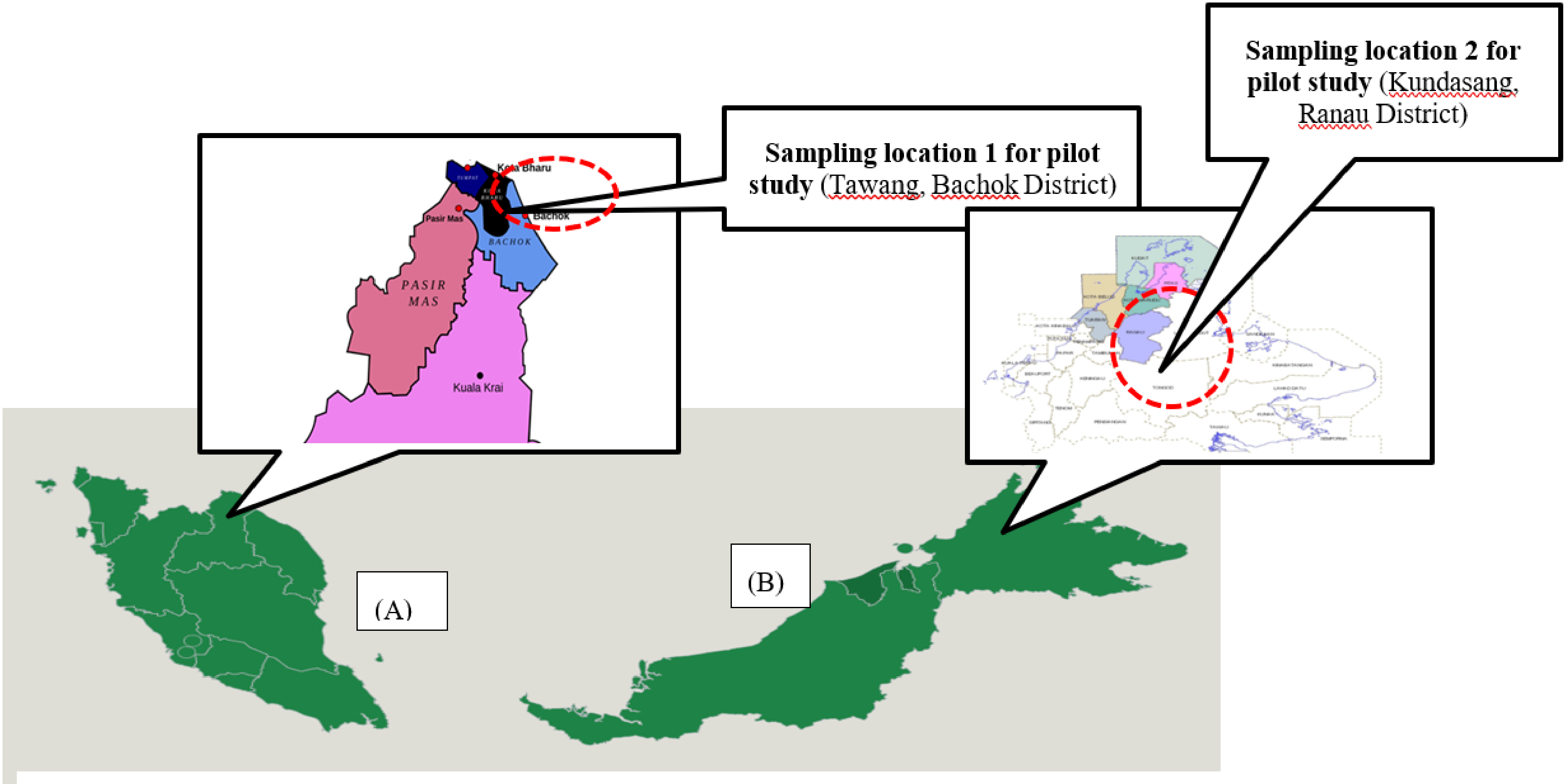


Figure 2.1: Map showing study area and sampling location for pilot study
(A) Malay peninsula, and (B) East Malaysia

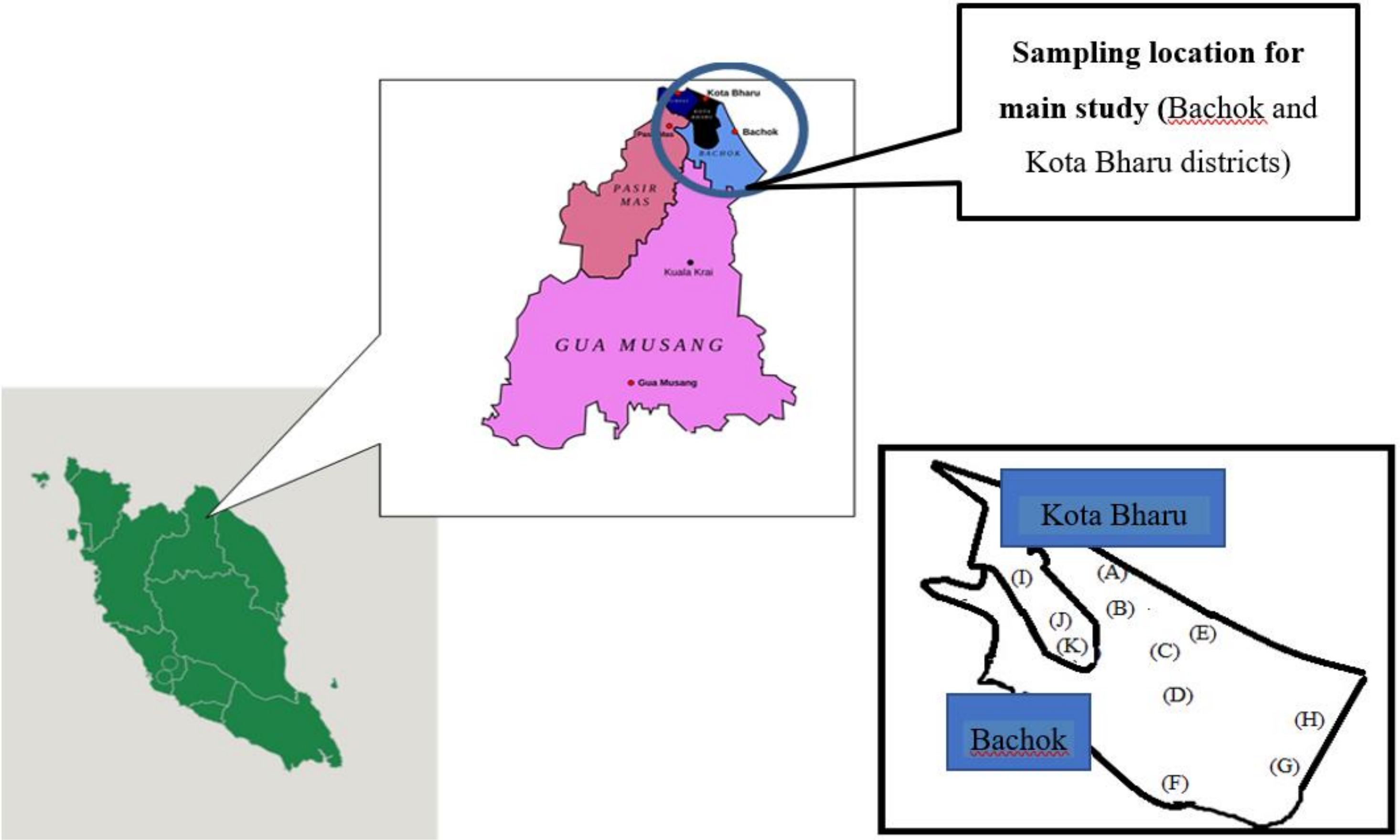


Figure 2.2: Map showing study area and sampling location for main study;
Bachok district (A) Tawang, (B) Perupok, (C) Tanjung Pauh, (D) Bekelam, (E) Melawi, (F) Mahligai, (G) Gunung, (H) Melawi;
Kota Bharu district (I) Kedondong, (J) Chenok, (K) Melor

2.3 ETHICAL APPROVAL

The study protocol and additional documents were reviewed and approved by the Malaysia Research Ethics Committee (NMRR-17-424-34635) on 3rd August 2017 (Appendix 1) and the Ethics Review Committee of University of Manchester (UREC 4327) on 7th February 2018 (Appendix 2). An amendment to the study received approval from the Ethics Review Committee of University of Manchester (UREC 4327) on 16th July 2018 (Appendix 3) and the Malaysia Research Ethics Committee (NMRR-17-424-34635) on 5th September 2018 (Appendix 4).

2.4 STUDY RECRUITMENT AND PARTICIPATION

2.4.1 Pilot study recruitment and participation

All farmers were identified from an agricultural department database in each district and field sampling was conducted from 14th February 2018 to 30th April 2018. The study recruitment and participant flow chart is shown in Figure 2.3.

Farmers were phoned by the research team before the first visit to determine their availability and if they were available, to confirm the date for the first visit. During this first visit, the researcher introduced himself as a method of building rapport and trust with the farmers. The farmers were given an introductory letter (Appendix 5), a participant information sheet (Appendix 6), a consent form (Appendix 7) and a screening questionnaire (Appendix 8). The farmers need to fill in a consent form and a screening questionnaire.

The participant information sheet contained contact details of the research team, in case the farmers needed further clarification or wished to withdraw from the study and the screening questionnaire contained questions on their current health status, somatic and neuropsychiatry symptoms. The researcher also asked when the farmer was going to start spraying. The farmers were given an opportunity to ask questions of any kind in order to clarify any doubts regarding the study. The farmers were then contacted via phone 24 hours later to confirm whether they were taking part in this study and each farmer who agreed to participate was asked to sign the consent form and answer the screening questionnaire which had been given during the first visit.

During the second visit which was two to three days later, the consent form and screening questionnaire were collected and the interview questionnaire (Appendix 9) was administered at the home of the farmers. The researcher interviewed the farmers in order to complete interview questionnaire. The interview questionnaire contained questions on demographics, lifestyle factors, reproductive history, work related information, farming and spraying information, re-entry into fields after spraying and their knowledge and practice of pesticide use. Farmers were also given two 60ml plastic containers for urine collection and an instruction leaflet for urine collection. Farmers were asked to collect a pre-spraying urine sample and then store the sample in their freezer. A time and date for the third visit was agreed.

The third visit was during a current spraying week. The pre-spraying urine sample was collected by the research team. Farmers were asked to collect a post-spraying urine sample during the evening of the first day of spraying and then store the sample in their freezer and the urine sample was collected by the research team on the second day of spraying session. The farmers were also asked to complete a 7-day diary to report any symptoms following the first day of pesticide use and also provide information about activities done during spraying week (Appendix 10). The farmer was observed during pesticide preparation and spraying during this visit so that the DREAM questionnaire could be completed (Appendix 11) (120).

The fourth and fifth visits were planned when the researcher went to meet farmers at the hospital. The farmer needed to come to the selected hospital for semen collection and analysis and also to answer hospital questionnaire (Appendix 12). The hospital question was to be completed by the farmers. The fourth visit was due to occur during a spraying session and the fifth visit was when the semen sample was collected during the non-spraying season around 3-9 months after the first day of current spraying session. Reimbursement was given to the farmers to cover cost for food and travelling to the hospital.

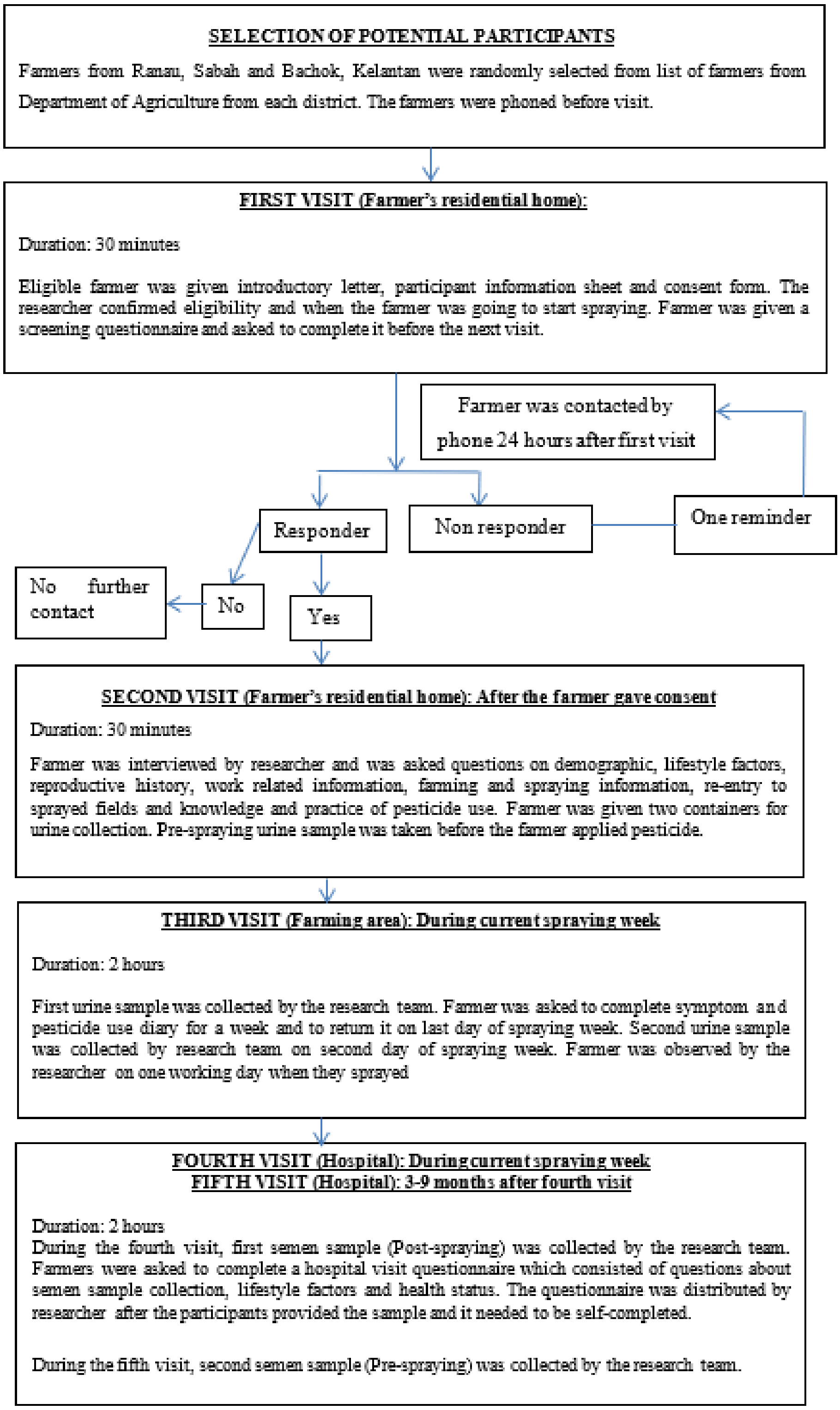


Figure 2.3: Recruitment and participant flow chart for pilot study

2.4.2 Main study recruitment and participation

Recruitment and participation in the main study was similar to that for the pilot study but with number of modifications outlined below. The recruitment and participant flow chart is shown in Figure 2.4. The farmers were identified from an Agricultural Department database of Bachok. The database was obtained from a list of farmers who attended courses or training conducted by the Agricultural Department. However, not all the farmers on the database were doing farming activities during the study period. A few farmers had moved to another district or had changed their phone number. Hence, additional farmers were recruited based on information obtained from other farmers. Data collection took place between September 2018 and February 2019.

The first, second and third visits of the main study were similar to those in the pilot study except that farmer did not complete a screening questionnaire during the first visit as the screening questionnaire was combined with the interview questionnaire (Appendix 13) which was administrated during second visit. During the third visit, a salivary sample was collected by the research team on the second day of spraying week.

Collection of semen samples and answering hospital questionnaire during the fourth visit during the pilot study was dropped. However, at the fourth visit of the main study, the research team came to the farmer’s home to collect self-reported health symptoms diary and the main study ended. The participant information sheet (Appendix 14) and consent form (Appendix 15) were also change due to change in study recruitment and participation.

2.5 DATA COLLECTION INSTRUMENTS

2.5.1 Questionnaires

The screening, hospital visit and self-reported symptom and spraying diary questionnaire was developed in English and translated into Malay Language and was back-translated into English. Meanwhile, the interview questionnaire was developed only in English language.

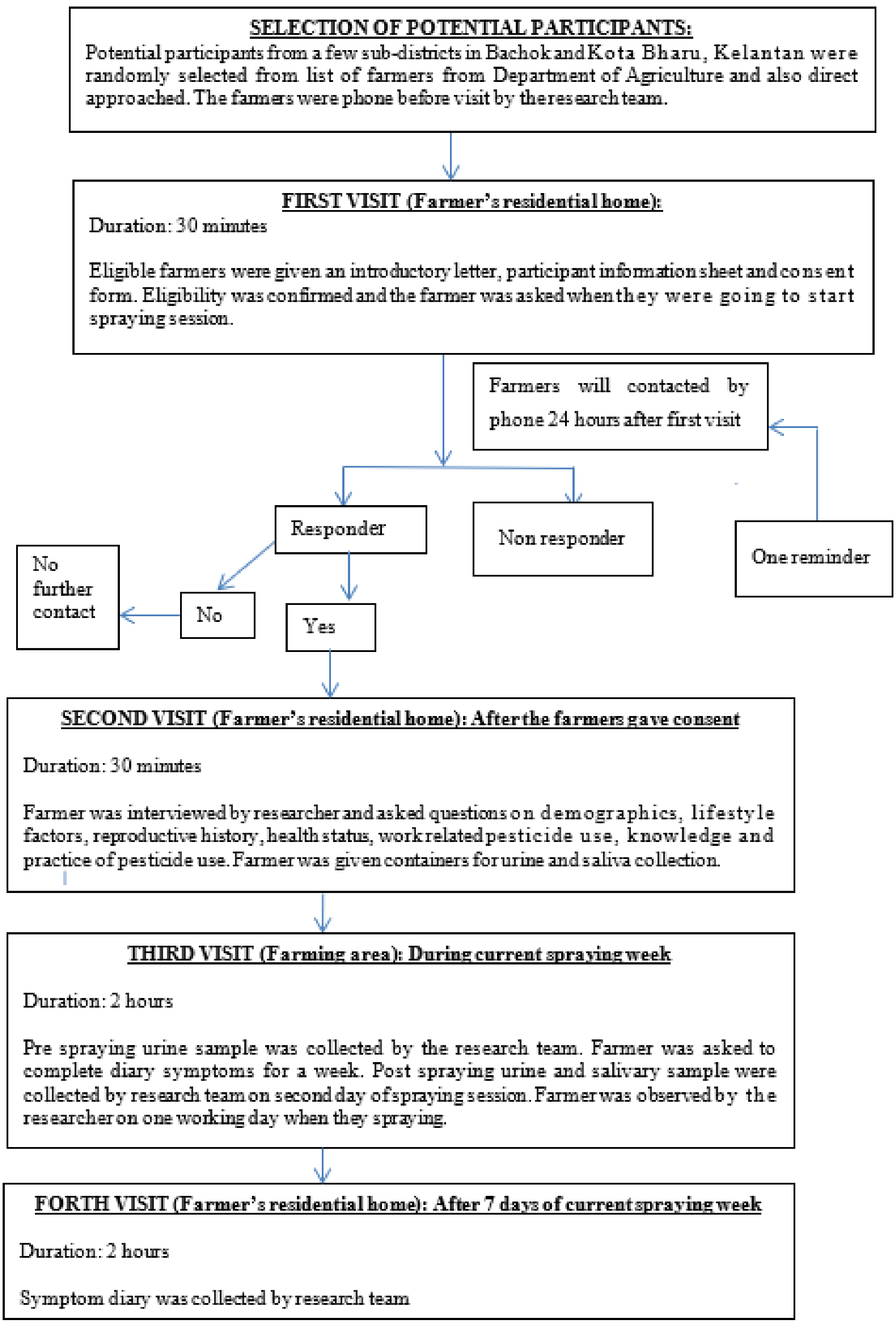


Figure 2.4: Recruitment and participant flow chart for the main study

2.5.1.1 Pilot study questionnaires

For the pilot study, the survey was conducted through self-completed and face-to-face interview questionnaires. Questionnaires were developed from those used by past studies in the UK (144–146) and Thailand (86). The research team also discussed and reviewed the questionnaires. The self-completed questionnaires were to be completed at the first visit (screening questionnaire), third visit (self-reported health symptom and spraying diary) and fourth visit (hospital visit questionnaire) and the face-to-face interview questionnaire during second visit.

The screening questionnaire was divided into two parts as follows; (a) current heath symptoms that asked questions on general health, and (b) somatic and neuropsychiatry symptoms. For the general health questions, the farmers needed to describe their current health status and any illness that was made worse by their work. The somatic and neuropsychiatry questionnaire consisted of questions on somatic symptoms (n=13), Parkinsonism/neuropathy (n=18), depression (n=11) and dementia (n=12). The hospital visit questionnaire was divided into four parts which consisted of (a) semen collection questions (n=3) that provided information on last day of ejaculation, method of semen collection and portion missed during ejaculation (b) lifestyle factor questions (n=3) that provided information on current status of smoking and alcohol consumption, whether the farmer wore jeans or not, (c) current health status questions (n=5) that provided information on any medical problems that caused participants to have radiotherapy or chemotherapy, or take any immunosuppressant drugs, or had had any x-rays , use of regular steroids, any fever or runny nose and illness that gets worse due to work, and (d) pesticide use question (n=1) that provided information on any exposure to pesticides again.

In the self-reported health symptom and spraying diary, farmers were asked to record symptoms that they had experienced for up to seven days following the start of a spraying week. The daily report consisted of 23 specific symptoms on health. The symptoms include feeling generally ill, feeling unusually tired, headache, anxiety, tremor, palpitation, excessive sweeting, runny nose, hoarse voice, sore throat, cough, shortness of breath, wheeze, nausea and vomiting, poor appetite, diarrhoea, muscle pain, dry mouth, lips and eyes, increased thirsty, passing less urine, urine more yellowish than normal and eye irritation. This diary symptom was based upon one used in a Thai study (86). In addition, farmers recorded information about activities done in the same week either spraying, re-entry into sprayed fields or not working.

Meanwhile, farmers were also interviewed using a questionnaire. This questionnaire contained eight parts as follows; a) demographic (n=7) characteristics (age, height, weight, ethnicity, marital status, level of education and income), (b) lifestyle factors (n=3) questions on diet, smoking and drinking habit, (c) reproductive history (n=2) including questions on investigation for fertility problems and number of children, (d) work related history (n=6) including questions on duration worked as a farmer, age start working, working history, size of farm and farm ownership, (e) farming, spraying and work practice information (n=19) including questions on total and current crops growing, total crops sprayed per year, task involved, average duration of spraying, date of last sprayed, whether mixed pesticides or not, application methods, PPE information, clothes worn while applying pesticides, clothes changing after pesticide exposure, showering behaviour after spraying, whether wash equipment or not, whether repaired spraying equipment or not, incidents while using pesticides, body parts exposed to pesticides, places where pesticide stored and current pesticide use, (f) re-entry to sprayed fields (n=10) including questions on being a bystander at a field being sprayed and re-enter into pesticide sprayed field, (g) knowledge of pesticide use (n=13), and (h) practice of pesticide use (n=16).

2.5.1.2 Main study questionnaires

Following the pilot study, numbers of alterations were made for the main study to the screening, hospital visit and the interview questionnaires to improve the accuracy of the responses, to ensure that questions could not be omitted inadvertently and to improve the clarity of some of the sections.

For the main study, the screening questionnaire was combined with the interview questionnaire and was administered at second visit. The interview questionnaire contained nine parts and no changes were made in the number and type questions asked for (a) demographic, (b) lifestyle factors, (c) work related history, (d) re-entry to sprayed fields, (e) knowledge of pesticide use and (f) practice of pesticide use. However, there were changes for following parts; (a) questions on current health status and somatic and neuropsychiatry symptoms were combined rather than being separate in screening questionnaire, (b) reproductive history with same number of questions (n=2) with details regarding pregnancy and delivery and (c) farming, spraying and working practice information were separated into farming and spraying information and work practice information. The number of questions for farming and spraying information was the same (n=2) with an additional question (n=1) on work practice information.

No changes were made in the self-reported symptom and spraying diary for the main study. However, since none of the farmers in the pilot study agreed to provide semen samples, the hospital visit question was omitted from main study.

2.5.2 Observation during spraying season

Field observations were conducted among farmers during the first day of a current spraying week for both the pilot and main studies. This was carried out during the third visit and the farmers were observed by the researcher when they were mixing and spraying pesticides. The farmer's spraying work was also recorded on video for completion of the DREAM checklist. The duration of observation lasted approximately 30 minutes for both mixing and spraying. The DREAM questionnaire was filled by the researcher team after observing and videoing famers while performing their tasks. The questions on the DREAM questionnaire have been described in Section 1.5.2.4.

2.5.3 Urine sample collection and analysis

Farmers were provided with two 60 ml plastic urine containers and an instruction leaflet for urine collection and storage (Appendix 16). Two spot urine samples were collected from each farmer to represented pre- and post-spraying samples. The pre-spraying sample was collected in the morning before the activity started and the post-spraying sample was collected during the evening of the first day of spraying between 6.00 and 8.00 pm if they sprayed in the morning or the next morning if the farmers sprayed at the evening.

The samples were immediately stored in a refrigerator at the farmer's home before being collected by the researcher. After the samples were collected by the researcher, they were kept were frozen at -20°C until delivery on dry ice to the Health

Safety Laboratory (HSL), Buxton, England for analysis. Only selected urine samples were analysed based on pesticides or metabolites that could be analysed at the HSL Laboratory. The laboratory is following ISO 9001 and other relevant quality control procedures (147). Figure 2.5 summarises urine sample collection, storage, transport and analysis.

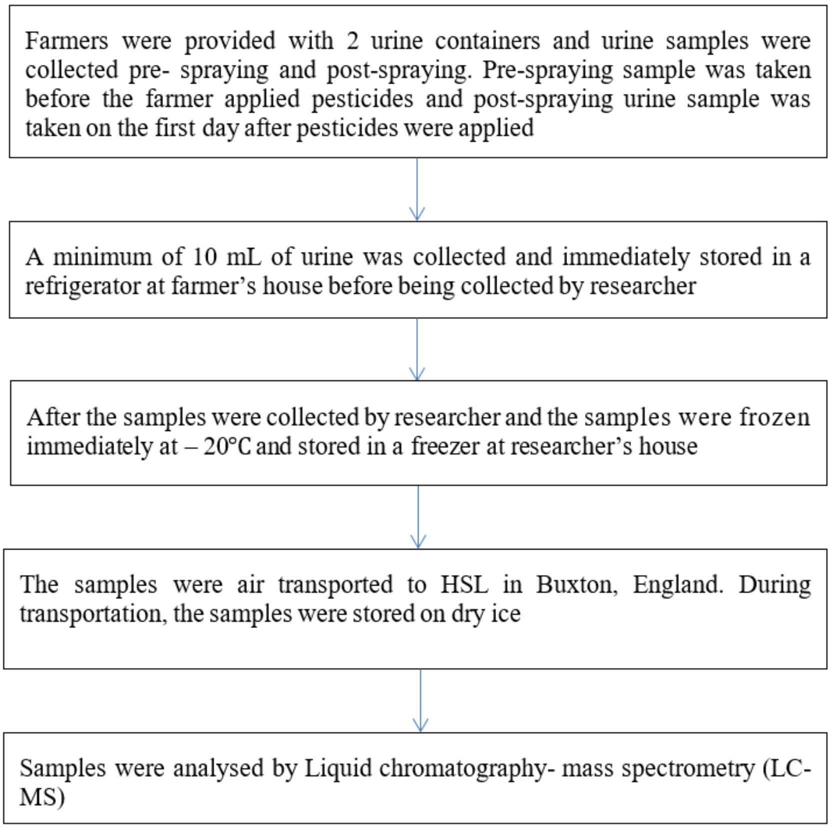


Figure 2.5: The process for urine collection, storage, transport and analysis

The list of analyses investigated comprised of pesticides or their metabolites and are summarised in Table 2.1. Validated analytical methods for pesticide metabolites were used at HSL. HSL also participates in external quality assurance schemes from Germany for chlorpyrifos and cypermethrin (148).

In brief, to quantify glyphosate levels, 200 µl aliquots of the urine samples were added to a tube containing 10 µl internal standards which consists of 100 µl glyphosate working solution (400 µg/l) to 1.9 ml of blank urine followed by 800 µl of milli Q water. The samples were then subject to solid phase extraction (SPE) and the glyphosate eluted using 10% formic acid in methanol. The eluent was evaporated under a gentle stream of nitrogen at 40ºC and reconstituted in 100 µl of 0.1% formic acid. The samples were ready for analysis by LC-MS (94).

Table 2.1: The measured metabolites and their parent compounds

Metabolite	LOD (µg/l)	Parental compounds
Bifenthrin	1	Pyrethroid
cDCVA	1	Cypermethrin
DBVA	1	Deltamethrin
Glyphosate	0.5	Glyphosate
3PBA	1	Pyrethroid
356TCP	1	Chlorpyrifos
tDCVA	1	Cypermethrin

A total of five pyrethroid metabolites including bifenthrin, 3PBA, tDCVA, cDCVA and DBVA and one chlorphyrifos metabolite (356TCP) were also measured. In brief, 1 ml aliquots of the urine samples were dispensed and 0.5 ml of 250 µl glucuronidase at 100,000 units/ml in 50 ml acetate buffer with pH 5 was added to all the samples. The samples were covered with parafilm and incubated overnight at 37ºC and 200 µl 1m acetic acid (5.7 ml acetic acid in 100 ml water) added C18 (1ml; 100 mg) SPE cartridges were pre-washed with 2 ml acetonitrile then 2 ml water and the acidified sample was added and washed with 2 ml water and the sample was eluted with 1 ml methanol followed by 1 ml acetonitrile. The eluent in clean tubes were collected and the samples were evaporated under a stream of nitrogen and reconstituted in 100 µl of 50% acetonitrile containing 1% acetic acid. All samples were assayed in duplicate and performed by LC-MS (149). Creatinine analysis was also completed on all urine samples and was determined using a Pentra 400 clinical analyser (150).

2.5.4 Semen sample collection and analysis

Semen samples were to be taken for assessing male infertility. However, it was dropped for the main study. The process for semen sample collection and analysis is discussed (Figure 2.6). Each farmer was provided with instructions for collecting of semen sample (Appendix 17). The semen samples were to be collected twice; the first sample collected at the fourth visit (during spraying session) and the second sample collected at the fifth visit (3-9 months after the first day of spraying session). All farmers were to be instructed to abstain from intercourse or any other forms of masturbation 2-3 days before collection of the semen sampling. The farmers also needed to avoid using any form of container or even condom because they might not be clean or contain chemicals which could contaminate the sample. On the day of appointment, semen collection was to take place in a private room in the hospital clinic. The farmers were provided with a clean and dry container and the sample collected by masturbation and all the semen ejaculated collected direct into the container. Semen sample was to be sent to be analysed within 1 hour of collection according to WHO procedures.

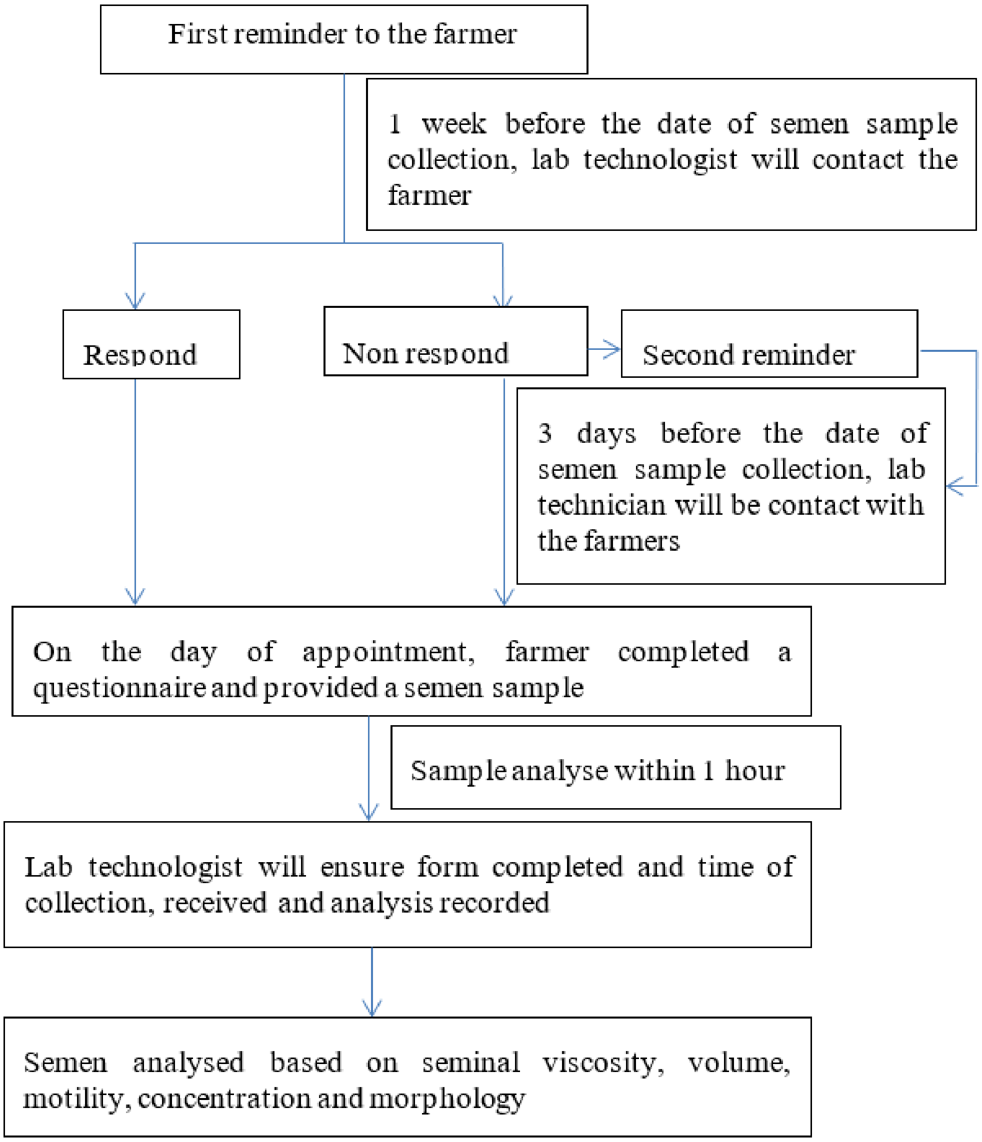


Figure 2.6: The process for semen collection and analysis

2.5.5 Saliva sample collection

A saliva sample was collected during the main study at the participant's home in the early morning (between 8.00 to 10. 00 am) in respect of the circadian rhythm of testosterone. The farmers were instructed not to eat, smoke, drink or brush their teeth 15 min prior to sampling and they were asked to spit the saliva directly into 60 ml container. The sample was frozen after collection at the researcher's home and stored at -20ºC prior to shipping and finally stored at -80ºC at The University of Manchester until analysed. Each farmer was provided with instructions for collecting of salivary sample (Appendix 18). Figure 2.7 shows the process for saliva collection, transport and analysis.

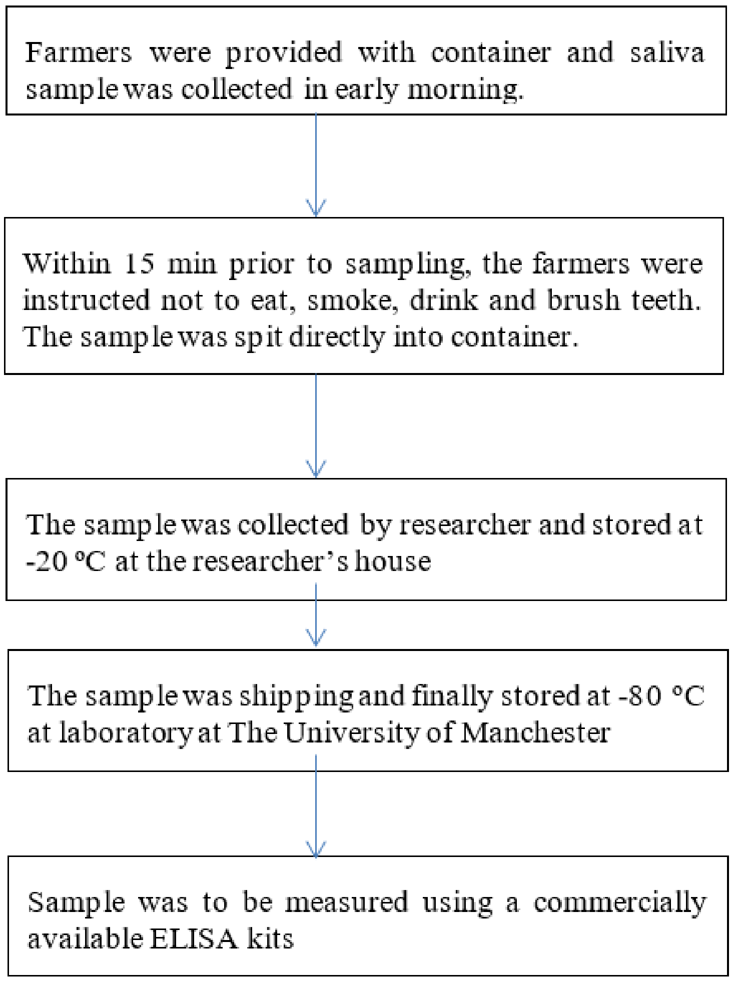


Figure 2.7: The process for saliva collection, transport and analysis

2.6 STATISTICAL ANALYSIS

Data were analysed using Statistical Package for Social Sciences Version (SPSS) Version 20 (IBM Corp). Based on study aims and objectives, a number of statistical analyses have been used.

2.6.1 Descriptive and inferential statistics

For categorical data, frequency and percentage were used to summarise each categorical variable. For numerical data, means, standard deviations (SD) and range for parametric numerical variables and median and (Q1-Q3) for non-parametric numerical variables were used. Histograms were used to explore the distributions.

To examine the association between categorical variables, a Chi-Square test was carried out, when more 20% of the expected counts and more than five counts were in all cells. If the assumption was not meet, Fisher Exact test was used.

To compare two independent groups for continuous variables, the Independent T-test was used when distributions were normal. If the data were not normally distributed, the Mann-Whitney U test was used. Meanwhile, to compare more than two groups, one-way analysis of variance (ANOVA) was used when distributions were normal. If the data were not normally distributed, the Kruskal-Wallis test was used. Paired T-test or Wilcoxon Signed Rank test was used to compare continuous variables and pre- and post-urine samples.

Associations between two continuous variables were analysed using the Pearson correlation. If not-normally distributed, the Spearman's rank correlation coefficient was used. A value close to 0 indicates no linear relationship, +1 indicates a positive relationship and -1 indicates a negative relationship between the variables. Correlations were interpreted using the following criteria; 0-0.3= weak correlation, 0.3-0.7= moderate correlation and greater than 0.7= strong correlation (151).

An intraclass correlation coefficient (ICC) estimate was used to analyse interrater reliability for DREAM score in order to determine the variation between four raters who observed the videos and completed DREAM questionnaire checklist. The estimates were based on mean-rating (n=4), absolute-agreement, 2 way mixed-effects model. Based on the 95% confident interval of the ICC estimate, values less than 0.50 is indicate poor reliability, between 0.50 and 0.75 indicate moderate reliability, between 0.75 and 0.90 good reliability and greater than 0.90 is excellent reliability (152).

A binary logistic regression model was used to investigate several categorical explanatory variables to predict the outcome such as pyrexial factor, PPE used, health status and neuropsychiatric symptoms and knowledge and practice of pesticide use. Univariate analysis was carried out for each variable. Following univariate analysis, all variables with a p value of less than 0.05 were included in final model. However, the variables such as EFS and AHS pesticide exposure intensity score and DREAM score were not included in this final model. This is because these scores included a variety of pesticide exposure variables. Forward and backward selection methods were used to compare which model was the best model. All independent variables were checked for multicollinearity and interaction. Goodness of fit was also checked and assumptions if met if the Hosmer-Lemeshow test p value was >0.05. After the assumption was met, the final model was achieved (153,154).

2.7 SAMPLE SIZE

Due to the nature of the pilot study, no sample size was calculated to determine how many participants were to be included in this study. The researcher and supervisory team agreed thus 10-20 were participants suitable for this pilot study. No power analysis was performed as well because this pilot study as focusing more on the practicalities of conducting this study.

For the main study, the sample size was decided based on semen samples parameters despite not collecting semen samples. This sample size also was used to obtain ethical approval.

The sample size calculation was based on data from Hossain et al. (14), obtained from a population similar to the one in the proposed study. Sperm concentration (10^6/ml), motility (%) and morphology (%) in the unexposed population was 55±29, 67±28, and 73±22 (mean ±SD), respectively.

Assuming α = 0.05, 80% power and a 25% drop out, to detect a sperm concentration in an exposed population of (i) 40×10^6/ml or (ii) 30×10^6/ml, 74 and 28 participants in each group would be required respectively.

Assuming α = 0.05, 80% power and a 25% drop out, to detect sperm motility in an exposed population of (i) 50% or (ii) 40%, 54 and 21 participants in each group would be required respectively

Assuming α = 0.05, 80% power and a 25% drop out, to detect sperm morphology in an exposed population of (i) 60% or (ii) 50%, 57 and 19 participants in each group would be required respectively. Hence, this study plan thus recruits approximately 150 farmers (75 farmers in each group).

2.8 OPERATIONAL DEFINITION OF VARIABLES

Table 2.2 shows the tool, type and operational definition for demographic variables. Table 2.3 shows the tool, type and operational definition for working histories and practices variables. Table 2.4 shows the tool, type and operational definition for exposure assessment variables. Table 2.5 shows the tool, type and operational definition for health outcome variables.

Table 2.2: The tool, type and operational definition for demographics variables

Variable	Tool/Type of variable	Definition and classification
Age	Interview questionnaire/ Numerical	Refers to the length of time that the farmers have lived from the date of birth until day of study is being carried out.
Ethnicity	Interview questionnaire/ Categorical	Refers to the ethnic group that the farmers belonged to. It was categorised into either Malay or non-Malay.
Body Mass Index (BMI)	Interview questionnaire/ Categorical	Refers to the farmers' body mass (kg) divided by the square of the body height (m^2) and expressed in units of kg/m^2. BMI was categorised into four groups according to Asian-Pacific cut-off points; underweight (<18.5 kg/m^2), normal weight (18.5-22.9 kg/m^2), overweight (23-27.5 kg/m^2) and obese (>27.5 kg/m^2) (155). For logistic regression analysis, BMI was categorised into either under/normal weight or overweight/obese.
Marital status	Interview questionnaire/ Categorical	Refers to the respondent's marital status Marital status was divided into three groups either single, married or widower/divorced. For logistic regression analysis, marital status was divided into either single or married/widower/divorced
Education level	Interview questionnaire/ Categorical	Refers to the highest level of formal education attended. The education level was divided into never been to school, primary school, secondary school or university. For logistic regression analysis, education level was divided into never been to school/primary school or secondary school/university.
Income per month	Interview questionnaire/ Categorical	Refers to money received on regularly monthly basis either from monthly salary or other source. It was classified as low income if the total salary per month was less than MYR 1500 (~£ 350) and middle income if salary was above (MYR 1501 to MYR 1000 (~£ 350 -~£1200)) (156) .
Diet habit	Interview questionnaire/ Categorical	Refers to food choices preferred by farmers in their daily life. The diet was divided into either meat and fish eater or fish eater only.

Smoking status	Interview questionnaire/ Categorical	Refers to the farmers that smoke cigarette, vape or cigars. Smoking status was classified into current, ex or non-smokers.
Age start smoking in current or ex-smokers	Interview questionnaire/ Numerical	Refers to the age of starting smoking among current or ex-smokers.
Cigarettes per day smoked by current smokers	Interview questionnaire/ Numerical	Refers to the number of cigarettes smoked per day among current smokers.

Table 2.3: The tool, type and operational definition for working histories and practices variables

Variable	Tool/Type of variable	Definition and classification
Age starting work as farmer	Interview questionnaire/ Numerical	Refers to the age of starting work as farmer.
Duration work as farmers	Interview questionnaire/ Numerical	Refers to duration that the farmers have been working as a farmer.
Type of farming	Interview questionnaire/ Categorical	Refers to what are farmers growing on the farm. It was divided into either rice farmers or vegetable/fruit farmers.
Farm size	Interview questionnaire/ Numerical	Refers to the size of farm that the farmers used.
Farm owner	Interview questionnaire/ Categorical	Refers to a farmer as an owner of the farming area. It was categorised into either yes or no.
Task involved	Interview questionnaire/ Categorical	Refers to activities that farmers routinely performed while handling pesticides which included diluting the concentrate, preparation and spraying. It was categorised into either yes or no.
Spraying per day	Interview questionnaire/ Numerical	Refers to the average duration of spraying in hours per day among the farmers.
Days sprayed per week	Interview questionnaire/ Categorical	Refers to the average duration of spraying in days per week among the farmers. It was categorised into 1 day or less, 2-3 days, 4-5 days and 6-7 days. For logistic regression analysis, it was categorised into either less than one day or two days or more.
Mixing pesticide	Interview questionnaire/ Categorical	Refers to the average time for mixing done by the farmers during handing pesticide. It was categorised into either < 50% of time or >50% of time.
Type of mixing system	Interview questionnaire/ Categorical	Refers to type of mixing equipment. It was categorised into either enclosed or open.
Application methods	Interview questionnaire/ Categorical	Refers to the main type of application that farmers used to spray. It was categorised into backpacker sprayer, power sprayer and blower. For logistic regression analysis, it was categorised either backpacker sprayer or power sprayer/blower.

Stored pesticides	Interview questionnaire/ Categorical	Refers to the place where the farmers normally store the pesticide. It was categorised into either in home, garage, attached out the building or field
Bystander at field being sprayed	Interview questionnaire/ Categorical	Refers to farmers who were working at field while somebody else sprays. It was categorised into either yes or no.
Re-enter into pesticide sprayed field	Interview questionnaire/ Categorical	Refers to farmers who worked in a pesticide sprayed field. It was categorised into either yes or no.
Incident while using pesticide	Interview questionnaire/ Categorical	Refers to an unpleasant or unusual event during pesticide handling which will expose farmers more to pesticides. It was categorised into either yes or no.
Part of body in contact with pesticide	Interview questionnaire and symptoms diary/ Categorical	Refers to nine body part exposed from anterior and posterior view to pesticide during work activities. It was categorised into either yes or no.
Change into clean clothes	Interview questionnaire and symptoms diary/ Categorical	Refers to changing into clean clothes of farmer after spraying pesticide. It was divided into either right away, later at the end of the day or next day or later in the week.
Shower after spraying pesticide	Interview questionnaire and symptoms diary/ Categorical	Refers to shower behaviour of farmers after spraying pesticide. It was divided into either right away, later at the end of the day or next day or later in the week.
Wash hand/arm after spraying pesticide	Interview questionnaire and symptoms diary/ Categorical	Refers to washing hand or arm of farmers after spraying pesticide. It was divided into either right away, later at the end of the day or next day or later in the week.
Repair spraying or mixing equipment	Interview questionnaire/ Categorical	Refers to farmers repairing their spraying or mixing equipment used during pesticide handling. It was categorised into either yes or no.
Clean equipment after pesticide use	Interview questionnaire/ Categorical	Refers to farmers washing the equipment after being used during pesticide handling. It was categorised into either yes or no.

Frequency clean spraying equipment	Interview questionnaire/ Categorical	Refers to the frequency of washing equipment after being used during pesticide handling among the farmers who wash the equipment. It was categorised into either always, most of the times, half of the times or sometimes.
Place clean spraying equipment	Interview questionnaire/ Categorical	Refers to the place where farmers who wash the equipment after being used during pesticide handling. It was categorised into either at farm or home.
Activity when clean spraying equipment	Interview questionnaire/ Categorical	Refers to the activity when cleaning the equipment among farmers who wash the equipment. It was categorised into either hose down the sprayer, clean nozzle or rinse tank.
Material used to clean the equipment	Interview questionnaire/ Categorical	Refers to the material used to clean the equipment among farmers who wash the equipment. It was categorised into sand only, water only, water and soap or cleaning agent.
Pesticide used	Symptoms diary and DREAM questionnaire / Categorical	Refers to the use of pesticides among the farmers on first day of current spraying session. If the pesticide is a mixture of two or more components, it was considered as one pesticide.
Amount of pesticide	DREAM questionnaire/ Categorical	Refers to the total amount of pesticide that the farmers used to sprayer the crop on the first day of current spraying session. It was categorised into less than 30 ml and more than 30 ml
Knowledge of pesticide use	Interview questionnaire/ Numerical and categorical	Refers to knowledge of pesticide use that is facts and information known by the farmers regarding pesticide use. Total knowledge scores were calculated as the sum of the correct responses to each question with one point given for a correct answer and 0 for an incorrect/do not know answer. The maximum and minimum scores were 13 and 0, respectively. The median total score was then used to categorise the farmers as having good knowledge (if farmers scored above median score) or poor knowledge (if farmers scored below median score) (157).
Practice of pesticide use	Interview questionnaire/ Numerical and categorical	Refers to practice of pesticide use before, during and after handling pesticides. Work practices scores were measured with a five-point Likert's scale. Answers were summed and maximum and minimum score were 64 and 0, respectively. A reverse score was given for negative items. All individual answers to practice questions were summed to obtain total scores. The median total score was then used to categorise the farmers as having a good practice score (if farmers

		scored above median score) and poor practice score (if farmers scored below median) (157).
PPE use	Interview questionnaire/ Categorical	Refers to equipment worn to minimize exposure to pesticides in this study. The farmers were considered to use PPE if they used at least one type of PPE while performing their occupational activities. The PPE use was divided into either yes or no.

Table 2.4: The tool, type and operational definition for exposure assessment variables

Variable	Tool/Type of variable	Definition and classification
Level of urine metabolites	Biomarker/ Categorical	Refers to the level of urine metabolites based on the difference between pre- and post-spraying levels of metabolites of chlorpyrifos, cypermethrin and pyrethroids. The difference between pre- and post-urine metabolite for each metabolite was classified into below (score=0) or above (score=1) the median. For each farmer, the median scores (below or above) for metabolites are summed and described as Minimal = Scores always below the median Low = Only one score above the median High = Two scores above the median Very high = All differ scores above the median For logistic regression analysis, the variable will be categorised based on either minimal/low or high/very high.
AHS score	Interviewed questionnaire/ Numerical	Refers to pesticide exposure intensity score based on AHS conducted in the USA. The score will be calculated based on weight score (Appendix 19).
EFS score	Interviewed questionnaire and symptoms diary/ Numerical	Refers to pesticide exposure intensity score based on EFS conducted in Ethiopia. The score will be calculated based on weight score (Appendix 19).
DREAM score	DREAM questionnaire/ Numerical	Refers to a score based on observational structured semi-quantitative method to assess dermal exposure for pesticide. The total DREAM scores will be calculated by adding nine body parts of actual dermal exposure (120).

Table 2.5: The tool, type and operational definition for health outcome variables

Variable	Tool/Type of variable	Definition and classification
Somatic symptoms	Interview questionnaire/ Categorical	Refers to all somatic symptoms be scored based on severity from 0 (not bothered), 1 (bothered a little) to 2 (bothered a lot). Individual somatic symptom scores were summed and then categorised as follows; minimal (lowest-16% of total score= 0-3), low (17%-34% of total score= 4-8), medium (35%-49% of total score= 9-12) and high (50% or more total score= 13-26) (158) .
Screen positive Parkinsonism	Interview questionnaire/ Categorical	Farmers screen positive for Parkinsonism were identified if they answered to one or more of C5(g), C5(h) and C5(i) question was bothered a lot in the past 4 weeks based on questions in interviewed questionnaire (Appendix 13) (159).
Screen positive neuropathy	Interview questionnaire/ Categorical	The farmers were identified as screen positive for neuropathy if their answer to one or more of C5(b), C5(d), C5(k), C5(m), C5(n), C5(p) and C5(r) was bothered a lot in the past 4 weeks based on questions in interviewed questionnaire (Appendix 13) (146).
Screen positive depression	Interview questionnaire/ Categorical	The farmers were determined to be screen positive for depression if they answer to C6(a) or C6(b) and 4 or more of C6(a) – C6(k) were at bothered a lot based on questions in interviewed questionnaire (Appendix 13) (160) .
Screen positive dementia	Interview questionnaire/ Categorical	The farmers were screen positive for dementia if they answer to C7(a),C7(i) or C7(j) based on questions in interviewed questionnaire (Appendix 13) and the severity cumulative score was greater than 4 or more if each positive answer was scored as 1 (161).
Somatic and neuropsychiatry symptoms (New classification)	Interview questionnaire/ Categorical	The farmers were classified either as not bothered or bothered at all for somatic and neuropsychiatry health symptoms where not bothered is when the response to all questions was not bothered and bothered at all when the response to one question (or more) was at least bothered a little.
Acute health symptoms	Symptoms diary/ Categorical	The farmers were considered as having symptoms if they had symptoms 48 hours after spraying at any time during the current spraying period. If the farmers reported having the same symptom on more than one occasion, the symptom was counted only one.
Pyrexial factor	Symptoms diary/ Categorical	Refers to four symptoms based on symptoms diary questionnaire occurring 48 hours after spraying at any time during current spraying period including feeling generally ill, unusually tired, sweaty, shivery, feverish, hot or cold and headache (145).
Respiratory factor	Symptoms diary/ Categorical	Refers to five symptoms based on symptoms diary questionnaire occurring 48 hours after spraying at any time during current spraying period such as runny, stuffy, blocked or irritated nose, cough, shortness of breath, wheeze and eye irritation occurring 48 hours after spraying at any time during current spraying period (145).

CHAPTER 3: EXPOSURE TO PESTICIDES AND HEALTH EFFECTS AMONG FARMERS IN TWO AREAS IN MALAYSIA- A PILOT STUDY

3.1 INTRODUCTION

Agricultural workers in Malaysia are often exposed to pesticides through various ways and workers occupationally exposed to pesticides on average have significantly higher exposures compared to the general population (162). Furthermore, many farmers practice improper handling of pesticides such as not using PPE, not following safety instructions provided and using more than the recommended pesticide dose (132).

Despite numerous benefits, the use of pesticides also brings a substantial hazard to the human and also environment. Numerous studies from lower and middle-income countries have indicated that acute health problems related to pesticide exposure account for significant morbidity and mortality (163,164). In addition, chronic pesticide exposure has been linked to a wide range of chronic health effects including influencing male fertility. However, research on the health effects of pesticide exposure in farmers is still limited in Malaysia and based only on surveys of self-reported health symptoms and signs (14,44,132,165).

It is uncertain whether the farmers would comply with the developed study protocol planned to assess the relationship between pesticide exposure and acute health effects among farmers. Therefore, a pilot study was undertaken to test the recruitment rate, the acceptability of conducting this study and to determine the feasibility of the study protocol.

3.1.1 Aims and objectives

The aims of this pilot study were to examine the feasibility of recruitment, retention of farmers as well as the collection of questionnaire data and biological samples (urine and semen) in order to obtained information related to pesticide exposure and health effects towards farmers. To achieve this, the specific objectives were to:

a) Determine the response and retention rate of the farmers

b) Assess the acceptability and understanding of the questionnaires and the diary to self-report symptoms

c) Determine the feasibility of collecting urine and semen samples and observing pesticide spraying

d) Obtain and analyse information about demographics, work practices, self-reported symptoms during the spraying season and biological samples (urine and semen samples)

e) Make recommendations for collecting data in the main study

3.2 RESULTS

3.2.1 Response rate of the farmers

Thirty farmers were approached to participate in the pilot study; 20 from Ranau, Sabah and 10 farmers from Bachok, Kelantan. The total response rate for this study was 60.0% (n=18). The highest response among the farmworkers was found in Bachok, Kelantan (80.0%, n=8) followed by Ranau, Sabah (50.0%, n=10). There was no loss of follow up observed in the pilot study (Figure 3.1).

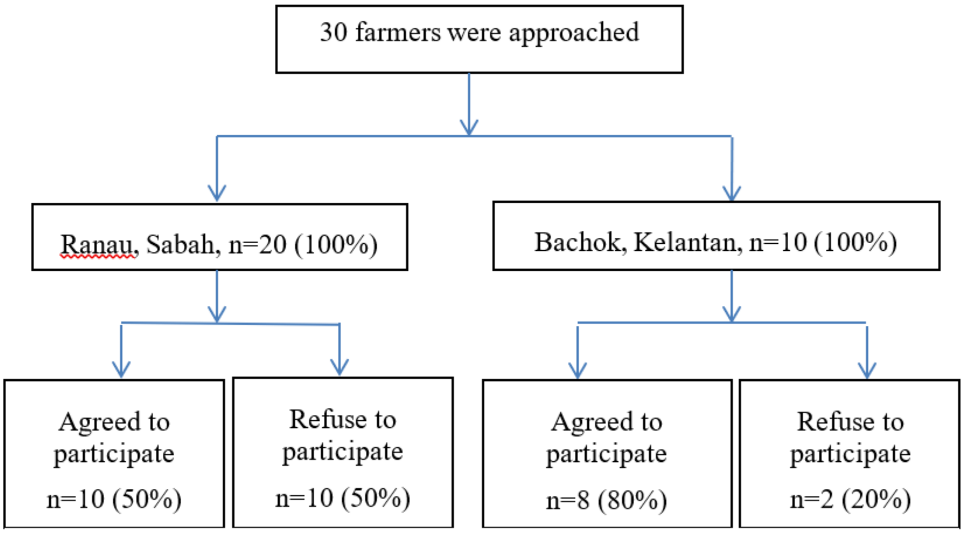


Figure 3.1: The response rate of the pilot study

3.2.2 Acceptability and understanding of study materials

For the screening questionnaire, the majority of the farmers were not keen to answer the questions as there was a list of questions which demotivated them to provide the answers. However, the farmers did not have any problems in answering the diary and the questions on self-reported symptoms. During the face-to-face interview and observation of pesticide spraying, the majority of the farmers gave their full cooperation and they did not have any problems.

In term of collection of biological samples, all the farmers gave their full commitment for the collection of urine samples but none of them agreed to give a semen sample.

3.2.3 Characteristics of farmers

Table 3.1 shows the demographic data for the 18 farmers. Farmers ranged in age from 27 years to 64 years and the mean $\pm$SD was 42.2$\pm$12.7 years. Malay and Dusun ethnic groups were the major respondents. All of the farmers from Kelantan were of Malay ethnicity but none of the farmers from Sabah were Malay ($p<0.01$). The vast majority of the farmers from Sabah were part of low income families compared to farmers from Kelantan where the majority were middle income ($p=0.04$).

3.2.4 Occupational histories and work practices of the farmers during previous spraying sessions

Table 3.2 describes the occupational histories and work practices of the farmers during previous spraying sessions. The mean $\pm$SD duration of working as farmers in this study were 18.8$\pm$14.8 and their mean $\pm$SD daily spraying hours was 1.6$\pm$0.9. All farmers were doing all the tasks such as preparation, diluting concentrate and spraying. All farmers from Sabah used a backpacker sprayer and 62.5% of farmers from Kelantan used a backpacker sprayer ($p=0.07$). There were no significant differences between occupational and work practices and whether the farmers worked in Sabah or Kelantan.

Table 3.1: The characteristics of farmers

Variable	Total (n=18)	Sabah (n=10)	Kelantan (n=8)	P value
Age, yrs				0.54 [a]
Mean±SD	42.2±12.7	40.5±12.5	44.4±13.6	
Min-Max	27-64	27-57	27-64	
BMI, n (%)				0.71 [b]
Underweight	1 (5.6)	0 (0.0)	1 (12.5)	
Normal weight	15 (83.3)	9 (90.0)	6 (75.0)	
Overweight	2 (11.1)	1 (10.0)	1 (12.5)	
Ethnicity, n (%)				<0.01 [b]
Malay	8 (44.4)	0 (0.0)	8 (100)	
Dusun	8 (44.4)	8 (80.0)	0 (0.0)	
Others	2 (11.2)	2 (20.0)	0 (0.0)	
Marital status, n (%)				0.31 [b]
Single	5 (27.8)	4 (40.0)	1 (12.5)	
Married	13 (72.2)	6 (60.0)	7 (87.5)	
Educational level, n (%)				0.78 [b]
Never been to school	1 (5.6)	0 (0.0)	1 (12.5)	
Primary school	4 (22.2)	3 (30.0)	1 (12.5)	
Secondary school	11 (61.1)	6 (60.0)	5 (62.5)	
University	2 (11.1)	1 (10.0)	1 (12.5)	
Income per month, n (%)				0.04 [b]
Low income	11 (61.1)	8 (80.0)	3 (37.5)	
Middle income	7 (38.9)	2 (20.0)	5 (62.5)	
Smoking status, n (%)				1.00 [b]
Current/ex-smokers	10 (55.6)	6 (60.0)	4 (50.0)	
Non-smokers	8 (44.4)	4 (40.0)	4 (50.0)	
Alcohol drinking, n (%)				Not examined
Yes	0 (0.0)	0 (0.0)	0 (0.0)	
No	18 (100)	10 (100)	8 (100)	

[a] P value by Independent T-test, [b] P value by Fisher Exact test

Table 3.3 shows PPE use and clothes worn by the farmers during previous spraying sessions. All farmers used PPE and the farmers from Sabah wore gloves more than farmers from Kelantan (p=0.03).

Table 3.4 shows the type of crops currently grown by the farmers. In the study period, nine different crops were cultivated. Sweet potato was the main crop grown by the farmers followed by onion and chilli but there were also differences between regions.

Table 3.2: Occupational histories and work practices of the farmers during the previous spraying sessions

Variable	Total (n=18)	Sabah (n=10)	Kelantan (n=8)	P value
Duration work as farmers, yrs				0.18 [a]
Mean±SD	18.8±14.8	14.6±14.0	24.1±14.9	
Min-Max	1-50	1-40	6-50	
Other jobs before becoming farmers, n (%)				0.15 [b]
Yes	6 (33.3)	5 (50.0)	1 (12.5)	
No	12 (66.7)	5 (50.0)	7 (87.5)	
Any additional job, n (%)				1.00 [b]
Yes	9 (50.0)	5 (50.0)	4 (50.0)	
No	9 (50.0)	5 (50.0)	4 (50.0)	
Farm owner, n (%)				0.48 [b]
Yes	16 (88.9)	8 (80.0)	8 (100)	
No	2 (11.1)	2 (20.0)	0 (0.0)	
Task involved, n (%)				Not examined
Diluting concentrate	18 (100)	10 (100)	8 (100)	
Preparation	18 (100)	10 (100)	8 (100)	
Spraying	18 (100)	10 (100)	8 (100)	
Duration of spraying per day, hour				0.69 [a]
Mean±SD	1.6±0.9	1.4±0.5	1.5±0.5	
Min-Max	0.5-4.0	0.5-2.5	1-4	
Mixed pesticide, n (%)				0.44 [b]
>50% of the time	17 (94.4)	10 (100)	7 (87.5)	
<50% of the time	1 (5.6)	0 (0.0)	1 (12.5)	
Duration of spraying per week, n (%)				1.00 [b]
1 day	10 (55.6)	6 (60.0)	4 (40.0)	
2-3 days	8 (44.4)	4 (40.0)	4 (40.0)	
Application methods, n (%)				0.07 [b]
Backpack sprayer	15 (83.3)	10 (100)	5 (62.5)	
Power sprayer	3 (16.7)	0 (0.0)	3 (37.5)	
Repair spraying or mixing equipment, n (%)				0.31 [b]
Yes	13 (72.2)	6 (60.0)	7 (87.5)	
No	5 (27.8)	4 (40.0)	1 (12.5)	
Store pesticide, n (%)				0.18 [b]
Yes, in home	1 (5.6)	0 (0.0)	1 (12.5)	
Yes, in garage	16 (88.8)	10 (100)	6 (75.0)	
Yes, in attached outbuilding	1 (5.6)	0 (0.0)	1 (12.5)	
Bystander farmers, n (%)				1.00 [b]
Yes	4 (22.2)	2 (20.0)	2 (25.0)	
No	14 (77.8)	8 (80.0)	6 (75.0)	
Work in pesticide sprayed field, n (%)				0.48 [b]
Yes	16 (88.8)	8 (80.0)	8 (100)	
No	2 (11.2)	2 (20.0)	0 (0.0)	
Incident while using pesticide, n (%)				0.64 [b]
Yes	9 (50.0)	4 (40.0)	5 (62.5)	
No	9 (50.0)	6 (60.0)	3 (37.5)	

[a] P value by Independent T-test, [b] P value by Fisher Exact test

Table 3.3: PPE use and clothes worn

Variable	Total (n=18)	Sabah (n=10)	Kelantan (n=8)	P value [a]
PPE used, n (%)				Not examined
Yes	18 (100)	10 (100)	8 (100)	
No	0 (0.0)	0 (0.0)	0 (0.0)	
Clothes worn when pesticide sprayed, n (%)				
Apron	2 (11.1)	2 (20.0)	0 (0.00)	0.48
Chemical resistant boots	14 (77.8)	6 (60.0)	8 (100)	0.10
Chemical resistant suits	0 (0.0)	0 (0.0)	0 (0.0)	Not examined
Dusk mask	4 (22.2)	3 (30.0)	1 (12.5)	0.59
Face shield	2 (11.1)	2 (20.0)	0 (0.0)	0.48
Gloves	8 (44.4)	7 (70.0)	1 (12.5)	0.03
Hat	14 (77.8)	8 (80.0)	6 (75.0)	1.00
Long sleeve shirt	15 (83.3)	10 (100)	5 (62.5)	0.07
Long trousers	15 (83.3)	10 (100)	5 (62.5)	0.07
Respiratory protection	0 (0.0)	0 (0.0)	0 (0.0)	Not examined
Shirt	15 (83.3)	10 (100)	5 (62.5)	0.07
Short	5 (27.8)	1 (10.0)	4 (50.0)	0.12
Shoes	8 (44.4)	6 (60.0)	2 (25.0)	0.19

[a] P value by Fisher Exact test

Table 3.4: Crops currently grown by the farmers

Crop	Total (n=18)	Sabah (n=10)	Kelantan (n=8)	P value [a]
Cabbage, n (%)	2 (11.1)	2 (20.0)	0 (0.0)	0.48
Chilli, n (%)	5 (27.8)	1 (10.0)	4 (50.0)	0.12
Cucumber, n (%)	4 (22.2)	0 (0.0)	4 (50.0)	0.02
Long bean, n (%)	2 (11.1)	1 (10.0)	1 (12.5)	1.00
Mushroom, n (%)	1 (5.6)	1 (10.0)	0 (0.0)	1.00
Mustard, n (%)	4 (22.2)	4 (40.0)	0 (0.0)	0.09
Onion, n (%)	7 (38.9)	5 (50.0)	2 (25.0)	0.37
Sweet potato, n (%)	8 (44.4)	3 (30.0)	5 (62.5)	0.34
Tomato, n (%)	4 (22.2)	4 (40.0)	0 (0.0)	0.09

[a] P value by Fisher Exact test

3.2.5 Pesticides used by farmers during first day of current spraying week

Table 3.5 shows the wide range of pesticides used by the farmers during first day of current spraying week. Eleven different types of pesticides consisting of fungicides, herbicides and insecticides, were used. Half of the farmers used a mixture of chlorpyrifos + cypermethrin. There was no association between type of pesticides used and whether the farmer worked in Sabah or Kelantan.

Table 3.5: Pesticides used by farmers during first day of current spraying week

Type of pesticide	Chemical class	Total (n=18)	Sabah (n=10)	Kelantan (n=8)	P value [a]
Fungicides, n (%)	Mancozeb	3 (16.7)	2 (20.0)	1 (12.5)	1.00
	Copper Oxychloride	1 (5.6)	0 (0.0)	1 (12.5)	0.44
	Propineb	1 (5.6)	0 (0.0)	1 (12.5)	0.44
Herbicides, n (%)	Glyphosate	1 (5.6)	0 (0.0)	1 (12.5)	0.44
Insecticides, n (%)	Chlorpyrifos+ Cypermethrin	10 (55.6)	7 (70.0)	3 (37.5)	0.34
	Abamectin	3 (16.7)	2 (20.0)	1 (12.5)	0.59
	Cypermethrin	2 (11.1)	1 (10.0)	1 (12.5)	1.00
	Chlorpyrifos	2 (11.1)	1 (10.0)	1 (12.5)	1.00
	Deltamethrin	2 (11.1)	2 (20.0)	0 (0.0)	0.48
	Dimethoate	1 (5.6)	0 (0.0)	1 (12.5)	0.44
	Malathion	1 (5.6)	0 (0.0)	1 (12.5)	0.44

[a] P value by Fisher Exact test

Table 3.6 shows the number of pesticides used by the farmers during first day of spraying. The majority of the farmers used a single type of pesticide. There was no association between number of pesticides used and whether the farmer worked in Sabah or Kelantan.

Table 3.6: Number of pesticides used by farmers during first day of current spraying week

Number of pesticides used, n (%)	Total (n=18)	Sabah (n=10)	Kelantan (n=8)	P value [a]
1	12 (66.7)	7 (70.0)	5 (62.5)	0.81
2	3 (16.7)	1 (10.0)	2 (25.0)	
3	3 (16.7)	2 (20.0)	1 (12.5)	

[a] P value by Fisher Exact test

3.2.6 Prevalence of self-reported symptoms within 48 hours of current spraying week among the farmers

On the day before spraying, none of the farmers reported that they felt ill. Ten farmers (55.5%) reported at least one symptom within 48 hours after pesticide use with six different symptoms being reported by the farmers (Table 3.7). 27.7% of the farmers reported a cough and feeling generally ill, followed by feeling unusually tired (16.7%) and having a runny nose, stuffy, blocked or irritated nose (16.7%). Only two of the farmers (11.1%) reported having a headache and sore throat. There was no significant difference in self-reported symptoms and whether farmers worked in Sabah or Kelantan.

Table 3.7: Self-reported symptoms within 48 hours of current spraying week

Symptoms, n (%)	Total (n=18)	Sabah (n=10)	Kelantan (n=8)	P value [a]
Cough	5 (27.7)	4 (40.0)	1 (12.5)	0.31
Feeling generally ill	5 (27.7)	2 (20.0)	3 (37.5)	0.61
Feeling unusually tired	3 (16.7)	2 (20.0)	1 (12.5)	1.00
Headache	2 (11.1)	0 (0.0)	2 (25.0)	0.18
Runny, stuffy, blocked or irritated nose	3 (16.7)	2 (20.0)	1 (12.5)	1.00
Sore throat	2 (11.1)	1 (10.0)	1 (12.5)	1.00

[a] P value by Fisher Exact test

Figure 3.2 shows the self-reported symptoms that were reported by the farmers on each day after the spraying week. A cough and sore throat occurred within 24 hours of spraying and resolved after 72 hours. Four symptoms (runny nose, headache, feeling generally ill and feeling tired) occurred 24 hours after spraying. Runny nose and headache resolved on the same day and feeling generally ill and tired resolved after 48 hours of symptoms. There was no significant difference in self-reported symptoms and farmers who used chlorpyrifos + cypermethrin and those who did not (Data not shown).

3.2.7 Level of urine metabolites of the farmers

3.2.7.1 Frequency of urine samples containing detectable urinary metabolites

Urine from farmers who reported using chlorpyrifos, cypermethrin, glyphosate or pyrethroids were analysed using methods as discussed in Section 2.5.3. In total, 18 urine samples were analysed. The proportion of urines with detectable metabolites is shown in Figure 3.3. The percentage of urines with detectable 356TCP was 100% for both pre- and post-spraying samples (18/18). The percentage of urine samples containing detectable levels of tDCVA, 3PBA and glyphosate was higher post-spraying (72.2% (13/18), 61.0% (11/18) and 44.4% (8/18), respectively) compared to

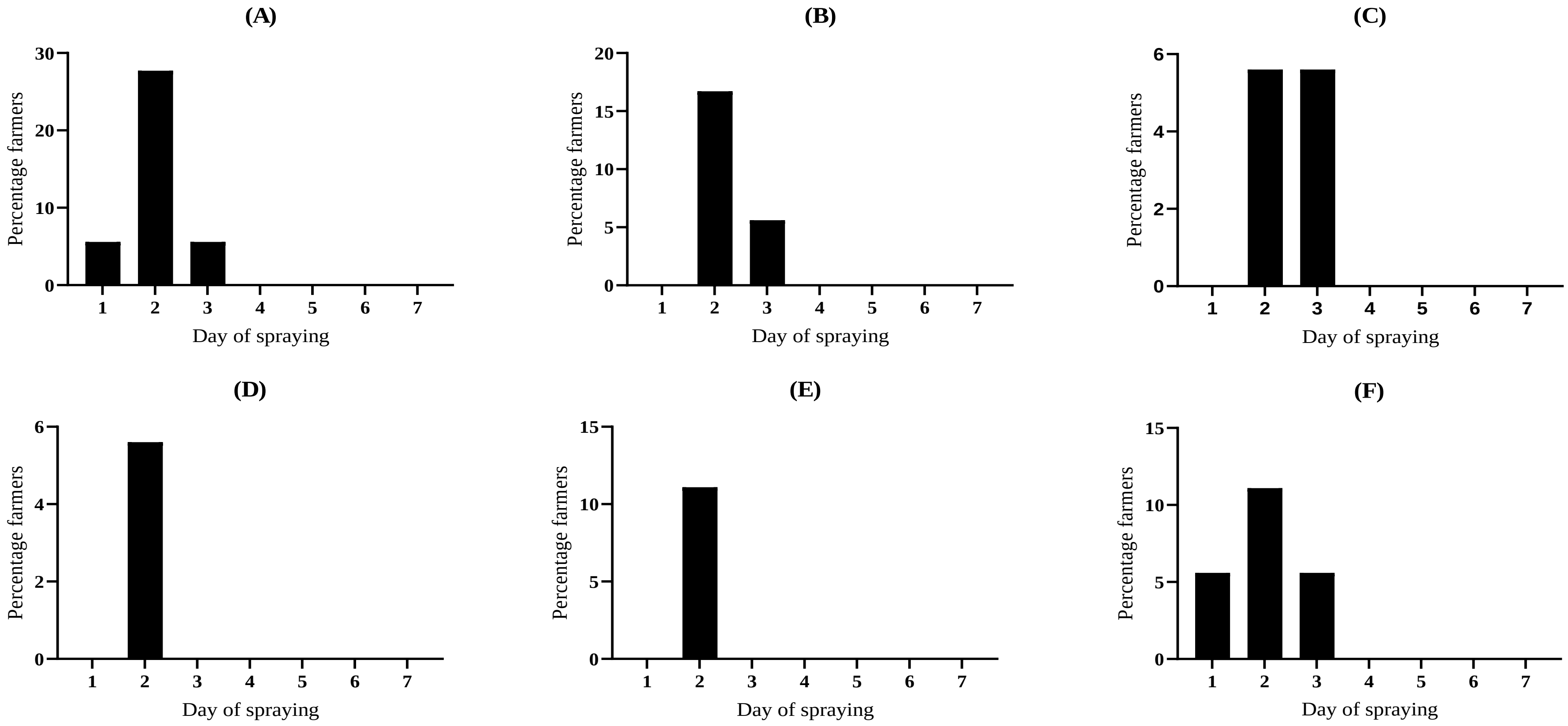


Figure 3.2 Self-reported symptoms during spraying week
(A) Cough, (B) Feeling generally ill, (C) Feeling unusually tired, (D) Headache, (E) Runny nose, and (F) Sore throat
*Scale of Y-axis is difference between graphs

pre-spraying (61.0% (11/18), 55.5% (10/18) and 27.8% (5/18)), respectively. The percentage of urines with detectable levels of cDCVA was similar pre- and post-spraying at 55.5% (10/18). Meanwhile, there was no detectable DBVA in urine samples from the farmers.

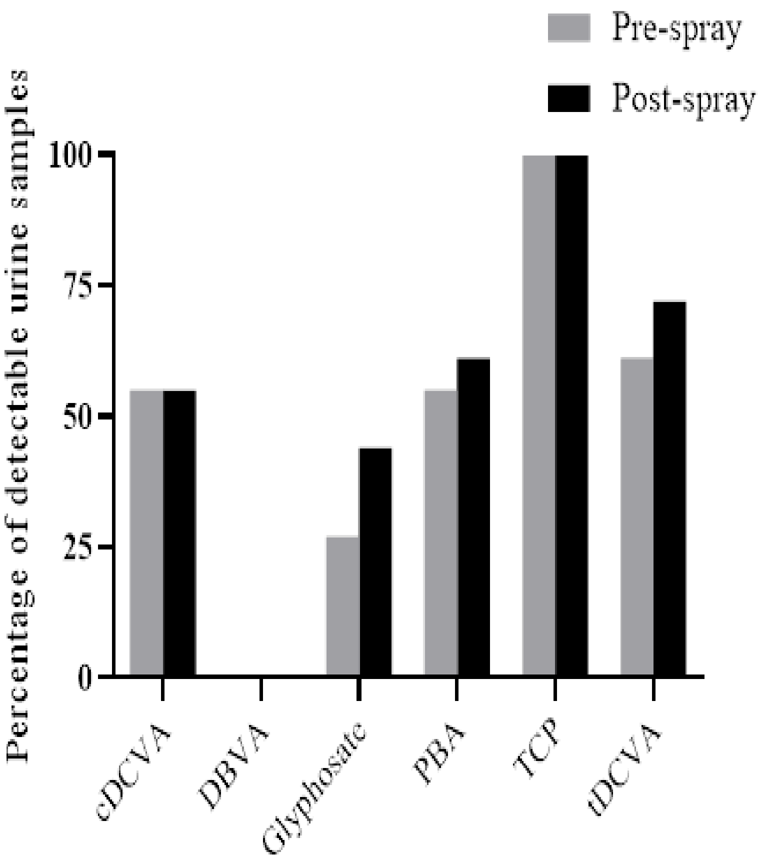


Figure 3.3: The proportion of urines with detectable metabolites among the farmers

3.2.7.2 Urinary metabolites among farmers who reported using or not using pesticides

Table 3.8 provides information on the urinary levels of pesticides and their metabolites adjusted for urinary creatinine levels among farmers who either used or not used pesticides. The median concentrations of these metabolites varied. There were no significant differences between post- and pre-spray levels among both groups. There was no significant association between level of urine metabolites and self-reported symptoms (Data not shown).

3.3 DISCUSSION

This pilot study was a feasibility study used mainly to examine the study protocol on exposure to pesticides and health effects among farmers and describe the information obtained on demographic, work practices, self-reported symptoms and biological samples. This pilot study was successfully conducted among 18 fruit and vegetable farmers in Bachok, Kelantan and Ranau, Sabah, Malaysia where the main activities are agricultural.

3.3.1 Statement of principal findings

This pilot study has demonstrated that the study protocol is feasible with some amendments and seems to be acceptable to all the participating farmers except for the collection of semen samples. The response rate was highest in Bachok area (80.0%) compared to Ranau area (50.0%) and no dropouts were identified. All of the farmers were compliant with answering interviewing questionnaires, completed self-reported diary symptoms, videoing during spraying week, and urines collection. However, none of them agreed to provide a semen sample.

3.3.2 Possible explanations of findings

A high response rate was achieved especially in Bachok, which indicates that it would be feasible to conduct the main study in this area. Meanwhile, a lower response rate was achieved in Ranau. The low response rate in Ranau may be attributed to most of the farmers being Indonesian and agency workers and it was difficult to approach and then recruit them. Whereas in Bachok, all of the farmers were local Malay people. Despite an overall good response rate from farmers, none of them agreed to provide a semen sample even though one study has been previously conducted in Sabah (14). This is largely due to religious issues as the majority of participants were Muslim.

The farmers usually combined different classes of pesticides in a single spray. Chlorpyrifos + cypermethrin were the most frequently used pesticides by the farmers in these two areas. These types of pesticides are class II (moderately hazardous) grade pesticides (166). In contrast, small scale farmers in other developing counties such as Bolivia and Vietnam, are still exposed to class I pesticides such as carbamate, methyl parathion and methamidophos, which are extremely hazardous (167,168). This is because Malaysia has banned the use of class Ia (extremely hazardous) and Ib (highly hazardous) pesticides, especially in rice farming activities (132). In addition, in many developing countries, the main problem is lack of regulation for pesticide registration (169).

Figure 3.4: The rice farmer using backpacker sprayer while spraying pesticide

During the spraying season, it is essential to have a proper sprayer. With regard to pesticide application procedures, a backpack sprayer was the most popular equipment used, but a few farmers did use an electric power sprayer. Figure 3.4 shows the rice farmer using backpacker sprayer while spraying pesticide. The main reasons why the farmers tended to use the backpack sprayer are because it is more practical and easier to carry since the farming area was only a small scale. The disadvantages of using a backpack sprayer that it is prone to leak especially between the pump and host and at the trigger valve (170).

Table 3.8: Urinary pesticide metabolites concentrations adjusted by urinary creatinine among farmers who either used or did not use a specific pesticide

Pesticide/ Metabolite [a]	Exposure	Farmers who used pesticide			Farmers who did not use pesticide		
		Median (Q1-Q3) mmol/mole creatinine; n			Median (Q1-Q3) mmol/mole creatinine; n		
		Post-spray	Pre-spray	Δ(Post-spray-pre-spray)	Post-spray Median	Pre-spray Median	Δ(post-spray-pre-spray)
cDCVA	Cypermethrin	0.2 (0.0-6.1); 12	0.5 (0.0-1.4); 12 [b]	0.0 (-0.5-4.4); 12	0.9 (0.0-2.1); 6	0.0 (0.0-0.8); 6 [b]	0.4 (-0.6-2.1); 6 [c]
Glyphosate	Glyphosate	0.0 (0.0-0.0); 1	0.0 (0.0-0.0); 1 [b]	0.0 (0.0-0.0); 1	0.0 (0.0-0.3); 17	0.0 (0.0-0.3); 17 [b]	0.0 (0.0-0.1); 17 [c]
3PBA	Pyrethroid	0.6 (0.0-2.7); 14	0.3 (0.0-1.0); 14 [b]	0.1 (-0.3-1.0); 14	0.2 (0.0-2.4); 4	0.8 (0.0-3.9); 4 [b]	-0.8 (-1.6-0.3); 4 [c]
356TCP	Chlorpyrifos	24.6 (10.8-49.0); 12	14.5 (9.1-42.7); 12 [b]	3.9 (0.4-10.8); 12	4.4 (3.2-42.5); 6	5.1 (3.5-38.7); 6 [b]	-0.4 (-7.2-3.3); 6 [c]
tDCVA	Cypermethrin	0.6 (0.0-8.3); 12	0.7 (0.0-2.1); 12 [b]	0.0 (-0.9-0.6); 12	1.0 (0.2-3.1); 6	0.1 (0.0-1.0); 6 [b]	0.5 (-0.3-1.9); 6 [c]

[a] Urinary metabolite level expressed as µmol/mole creatinine, [b] P value $\geq$0.05 by using Wilcoxin Signed Rank Test difference between post- and pre-spray level in farmers who used pesticide or did not used pesticide, [c] P value $\geq$0.05 by Mann-Whitney U test difference in post- and pre-spray level between farmers who used and did not used pesticide.

The present study showed that majority of the farmers stored the pesticides in the garage. Figure 3.5 shows the garage where the farmers mainly store the pesticide. This practice is very good and reduces hazardous risks to children as well as other family members.

Figure 3.5: The garage where the farmers mainly store the pesticide

Farmers reported several symptoms during pesticide spraying. The results showed that the most common were respiratory symptoms such as cough, runny nose, and sore throat and neurology and nicotinic side effects such as headache, feeling generally ill and tired. The respiratory symptoms may have arisen because none of the participants wore a respiratory mask and only 22.3% wore a dust mask leaving their head and face exposed to pesticides. Respiratory symptoms are caused by smoking (171). However, the respiratory symptoms in this study were not aggravated by the smoking habit of the farmers, even though the majority of the farmers were active smokers. Having said that, there were no other reports related to the dermal, eye and also neuropsychiatric symptoms.

The use of PPE during pesticide application was common among study farmers, but none of the farmers wore respiratory protection, goggles or chemically resistant suits. The reasons for not using protective equipment during pesticide spraying were due to hot weather and discomfort, especially at midday.

Based upon the five metabolites measured in the urine of the farmers, no significant differences in metabolite concentrations were observed between exposed and unexposed farmers. The statistical power to detect differences in urinary metabolite level was limited due to small sample size, which was not sufficient for robust statistical analysis. However, an interesting observation is the level of detectable metabolites in this study was higher for four metabolites namely 356TCP, tDCVA, 3PBA and cDCVA, which may indicate that the farmers were exposed occupationally to pesticide.

3.3.3 Limitations of pilot study and recommendations for main study

The pilot study identified several limitations that needed to be addressed for the main study. These changes were based on information that was obtained while conducting the pilot study and were anticipated to improve the study protocol, the accuracy of the responses and the clarity of some of the sections. This is believed to be beneficial to the participants and the research team.

The proposed changes include;

a) Study setting

The study setting should be changed to Kelantan state rather than be in Sabah. The rationale for this change was the lower participation rate in Sabah in part because the farmers in this area were difficult to approach and recruit which we ascribed to them not being native Malay but largely Indonesian and agency workers. A change in area to one with more Malay farmers is thus proposed to improve the response rate.

b) An additional collection of biological samples

No man was willing to provide a semen sample. Hence, a saliva sample should be collected to assess male reproductive function by measuring testosterone level. The alternative approach of collecting a blood sample was rejected because a saliva sample is easier and more convenient to collect and is non-invasive. This approach would not have the same level of anxiety and discomfort associated with blood sampling. In addition, the samples can be collected at home without going to a clinic.

b) Changes in questionnaire administration

Two, rather than three, questionnaires should be used for the main study. This can be achieved by combining the initial screening questionnaire with the interview questionnaire. This is suggested because most of the farmers did not complete the screening questionnaire. Some of the questions in the questionnaires were identified as being unclear and needed minor changes to the wording. The rationale for the changes was to clarify certain questions or remove unsuitable and unclear questions that had no response in the pilot study.

3.4 CONCLUSION

This chapter had demonstrated the importance of conducting a pilot study. Overall, this pilot study provided useful information on various aspects of the feasibility of conducting a study to collect biological samples among the farmers. The original intention was to collect semen samples, but that was not feasible. Otherwise, this study found the farmers appear to be exposed to the pesticide occupationally as suggested by the high level of detectable metabolites in urinary samples and was supported by health symptoms occurring after pesticide use. Further studies are needed to determine the association between exposure and health symptoms. So, this pilot study has provided clear ideas to the research team for improving the study protocol and expanding this into a more extensive study (main study) as described later.

CHAPTER 4: DEMOGRAPHICS, WORKING PRACTICES, PESTICIDE EXPOSURE AND HEALTH STATUTS OF FARMERS – THE MAIN STUDY

4.1 INTRODUCTION

The use of pesticides plays a pivotal role in countries like Malaysia where agriculture is an important contributor to the country's income. However, the use of pesticides can be accompanied by health issues and occupational exposure to pesticides can be an important exposure pathway for farmers. When farmers are exposed to a pesticide, it is important to recognise risk factors associated with pesticide exposure such as duration, frequency and intensity of application, method used, safety and hygienic behaviours (58–60).

Various ways of assessing exposure to pesticides have been described such as using semi-quantitative assessments such as predictive algorithms (113,117), DREAM (120) and also quantitative assessment such as biomarkers (74). In many developing countries, there is a lack of occupational hygiene regulations and semi-quantification dermal exposure to pesticide more widely used than quantitative assessment.

The pilot study suggested that the Malaysian farmers were exposed to pesticides during pesticide handing. This suggests a potential public health impact that may be widespread in the country. However, the amount of information in this pilot study was limited mainly due to small sample size which may be unrepresentative. This suggests the need for further studies on assessing pesticide exposure and health effects among farm workers, including a focus on improved exposure assessment. Hence, a larger study was carried out in Malaysian farmers to assess pesticide exposure Pesticide exposure is considered a global health problem and this issue is even more obvious in developing countries such as Malaysia, where it is a serious concern as it can adversely affect occupationally exposed workers such as farmers. However, pesticide exposure does not get a serious amount of attention from authorities as the chronic health effects are initially subtle (172).

4.1.1 Aims and objectives

The overall aim of the main study was to determine associations between pesticide exposure and acute ill-health in farmers. In this chapter, the demographics of the study population are described together with their working practices, chronic ill-health and pesticide exposure and determinants of this exposure are examined.

The specific objectives of the work in this chapter were to

a) Describe the demographics of the farmers across the different farm types
b) Describe working practices of the farmers during previous spraying sessions across the different farm types
c) Adapt existing AHS and EFS pesticide exposure intensity algorithm models to the study population to estimate pesticide exposure intensity scores
d) Estimate pesticide exposure based on dermal exposure using (DREAM)
e) Determine the correlation between the DREAM score and AHS and EFS pesticide exposure intensity algorithm scores
f) Determine the associations between AHS and EFS pesticide exposure intensity scores and DREAM scores and demographics
g) Quantify the level of urine metabolites pre- and post-spraying and determine the relationship between the level of urine metabolites and demographic factors and pesticide exposure
h) Investigate the nature of ill-health
i) Estimate the prevalence of somatic and neuropsychiatric ill-health including Parkinsonism, neuropathy, depression and dementia
j) Examine the associations between ill health and demographic factors, working practices during previous spraying sessions and pesticide exposure

4.2 RESULTS

The data in this study were based on either previous spraying session or current spraying week. For the previous spraying session, the information was collected by the interview questionnaire, taken during the second visit. For current spraying week, the information was based on either the spraying diary or the DREAM questionnaire which was collected during third or fourth visit.

4.2.1 Demographics and working practices of farmers

4.2.1.1 Response rate

Figure 4.1 shows the response rate of the main study population. There were 210 farmers who met the inclusion criteria and who farmed rice or vegetables and fruits. Of these 210 eligible farmers, 174 responded to the invitation and there were 36 non responders due to being unable to contact them. A total of 150 farmers agreed to participate in the study. Twenty-four eligible farmers were excluded because they were not interested (n=14) or did not spray (n=10). All of the farmers completed the study without loss of follow up.

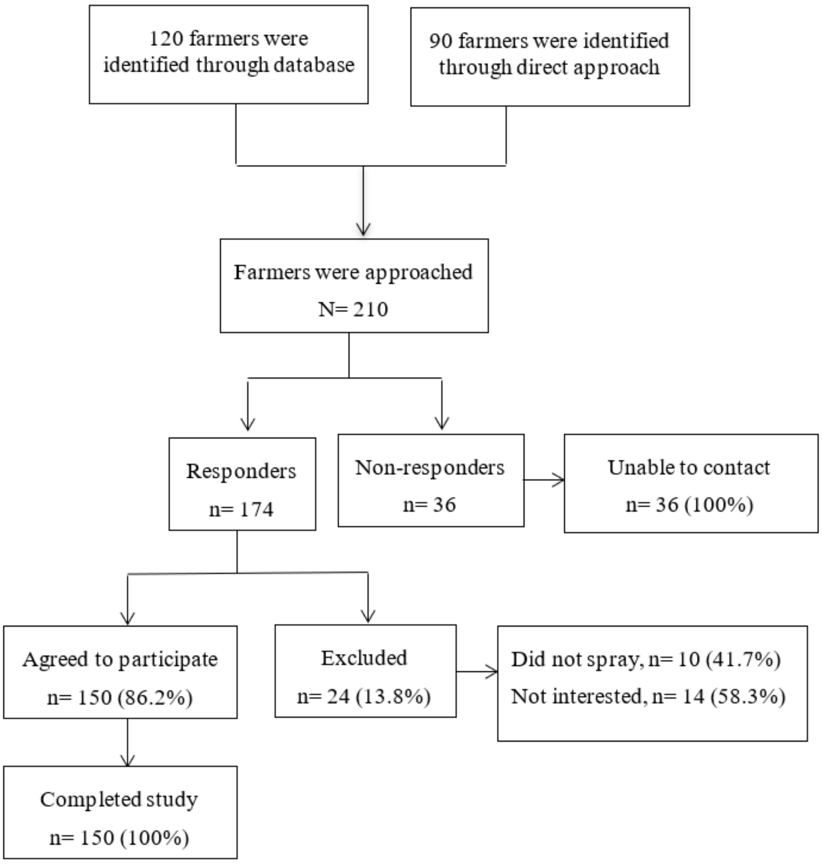


Figure 4.1: The response rate of the main study population

4.2.1.2 Demographics characteristics of the farmers

Table 4.1 shows the demographic characteristic of farmers. The mean± SD age of the farmers was 47.6±15.8 years with ages ranging between 17 and 81 years old, which was similar between the rice and vegetable/fruit farmers. All of the farmers that participated in this study were male and almost exclusively Malay. Most of them were married (80.7%), had completed a secondary education level (58.0%), had a low income (58.0%) and were current or ex-smokers (70.0%). 13.4% of vegetable/fruit farmers had had tertiary education compared to only 3.6% of rice farmers ($p<0.05$).

Table 4.1: The characteristic of farmers

Variable	Total (n=150)	Type of farming		
		Rice (n=83)	Vegetable/ Fruit (n=67)	P value
Age, yrs				0.89 [a]
Mean±SD	47.6 ±15.8	47.7±16.4	47.4±15.2	
Min-Max	17-81	17-77	22-81	
Ethnicity, n (%)				1.00 [b]
Malay	149 (99.3)	82 (98.8)	67 (100)	
Other	1 (0.7)	1 (1.2)	0 (0.0)	
BMI, n (%)				0.23 [b]
Under weight	10 (6.7)	8 (9.6)	2 (3.0)	
Normal weight	96 (64.0)	55 (66.3)	41 (61.1)	
Overweight	37 (24.7)	17 (20.5)	20 (29.9)	
Obesity	7 (4.6)	3 (3.6)	4 (6.0)	
Marital status, n (%)				0.83 [b]
Single	26 (17.3)	14 (16.9)	12 (17.9)	
Married	121 (80.7)	68 (81.9)	53 (79.1)	
Widowed/Divorced	3 (2.0)	1 (1.2)	2 (3.0)	
Educational level, n (%)				<0.05 [b]
Never been to school	10 (6.7)	4 (4.8)	6 (9.0)	
Primary school	41 (27.3)	21 (25.3)	20 (29.9)	
Secondary school	87 (58.0)	55 (66.3)	32 (47.8)	
University	12 (8.0)	3 (3.6)	9 (13.4)	
Income per month, n (%)				0.79 [c]
Low income	87 (58.0)	46 (55.4)	41 (61.2)	
Middle income	63 (42.0)	37 (44.6)	26 (38.8)	
Diet habit, n (%)				1.00 [b]
Meat and fish eater	147 (98.0)	81 (97.6)	66 (98.5)	
Fish eater	3 (2.0)	2 (2.4)	1 (1.5)	
Smoking status, n (%)				0.97 [c]
Current smoker	90 (60.0)	47 (56.6)	43 (64.2)	
Ex-smoker	15 (10.0)	11 (13.3)	4 (5.9)	

Non-smoker	45 (30.0)	25 (30.1)	20 (29.9)	
Age start smoking in current or ex-smokers, yrs (n=105) Mean±SD Min-Max	 19.3±6.4 12-50	 18.7±7.0 12-50	 20.0±5.6 13-42	0.32 [a]
Cigarettes per day smoked by current smokers, sticks (n=90) Mean±SD Min-Max	 14.9±9.3 1-60	 15.6±11.0 1-60	 14.0±7.0 2-25	0.41 [a]

[a] P value by Independent T-test, [b] P value by Fisher Exact test, [c] P value by Chi-Square test

4.2.1.3 Occupational histories information and work practices during previous spraying sessions

Table 4.2 provides information on farmers' occupational histories and work practices during previous spraying sessions. Rice farmers have larger farms than vegetable/fruit farmers with a median (Q1-Q3) size of a rice farm being 8.0 (4.0-17.0) acres and for vegetable/fruit farmers 2.0 (1.0-3.0) acres ($p<0.01$).

The duration of spraying per day and per week was higher for rice farmers than vegetable/fruit farmers. The majority of the rice farmers sprayed 2-3 days a week while most of the vegetable/fruit farmers sprayed one day or less in a week ($p<0.01$). Rice farmers sprayed with median (Q1-Q3) of 2.0 (1.0-2.0) hours per day, while vegetable/fruit farmers sprayed with median (Q1-Q3) of 1.0 (1.0-2.0) hours per day ($p<0.01$).

Among rice farmers, 49.4% used a backpacker sprayer whereas 97.0% of vegetable/fruit farmers used a backpacker sprayer ($p<0.01$). 26.5% of rice farmers and 14.9% of the vegetable and fruit farmers were a bystander when a field was sprayed ($p=0.03$).

32.5 % of rice farmers had experienced an incident while using pesticides compared to only 13.4% of vegetable/rice farmers ($p<0.01$). More than 70.0% of incidents were due to leakage of the pesticide and the remaining was due to spillage of the pesticide. These incidents occurred less than one day per month for all farmers who were involved.

Table 4.2 Occupational histories and working practices of the farmers during previous spraying sessions

Variable	Total (n=150)	Type of farming		
		Rice (n=83)	Vegetable/ Fruit (n=67)	P value
Age start working, yrs				0.30 [a]
Median (Q1-Q3)	18 (15.0- 18.0)	18 (15.0-20.0)	18 (16.0-20.0)	
Duration work as farmers, yrs				1.00 [a]
Median (Q1-Q3)	20 (6.0-20.0)	20 (6.0-36.0)	18 (7.0-18.0)	
Farm size, acres				<0.01 [a]
Median (Q1-Q3)	4.0 (2.0-4.0)	8.0 (4.0-17.0)	2.0 (1.0-3.0)	
Farm owner, n (%)				1.00 [b]
Yes	148 (98.7)	81 (97.6)	67 (100)	
No	2 (1.3)	2 (2.4)	0 (0.0)	
Task involved, n (%)				
Diluting concentrate	147 (98)	80 (96.4)	67 (100)	0.25 [b]
Preparation	148 (98.7)	81 (97.6)	67 (100)	0.50 [b]
Spraying	150 (100)	83 (100)	67 (100)	
Spraying per day, hour				<0.01 [a]
Median (Q1-Q3)	2.0 (1.0-2.0)	2.0 (1.0-2.0)	1.0 (1.0-2.0)	
Days sprayed per week, n (%)				<0.01 [b]
1 day or less	38 (25.3)	7 (8.4)	31 (46.2)	
2-3 days	83 (55.3)	54 (65.1)	29 (43.3)	
4-5 days	19 (12.7)	14 (16.9)	5 (7.5)	
6-7 days	10(6.7)	8 (9.6)	2 (3.0)	
Mixing pesticide, n (%)				0.66 [b]
<50% of time	5 (3.3)	2 (2.4)	3 (4.5)	
>50% of time	145 (96.7)	81 (97.6)	64 (95.5)	
Type of mixing system, n (%)				Not examined
Enclosed	0 (0.0)	0 (0.0)	0 (0.0)	
Open	150 (100)	83 (0.0)	67 (100)	
Application methods, n (%)				<0.01 [b]
Backpack sprayer	106 (70.7)	41 (49.4)	65 (97.0)	
Power sprayer	20 (13.3)	18 (21.7)	2 (3.0)	
Blower	24 (16.0)	24 (28.9)	0 (0.0)	
Stored pesticides				0.11 [c]
In home	13 (8.7)	7 (8.4)	6 (6.1)	
In garage	87 (58.0)	55 (66.3)	32 (48.5)	
In attached out building	27 (18.0)	13 (15.7)	14 (21.2)	
In the field	22 (14.7)	8 (9.6)	14 (21.2)	
Bystander at field being sprayed, n (%)				0.03 [c]
Yes	32 (21.3)	22 (26.5)	10 (14.9)	
No	118 (78.7)	61 (73.5)	57 (85.1)	
Re-enter into pesticide sprayed field, n (%)				0.25 [c]
Yes	38 (25.3)	18 (21.7)	20 (29.9)	
No	112 (74.7)	65 (78.3)	47 (70.1)	
Incident while using pesticide, n (%)				<0.01[c]
Yes	36 (24.0)	27 (32.5)	9 (13.4)	
No	114 (76.0)	56 (67.5)	58 (86.6)	
Nature of incident (n=36), n (%)				1.00 [b]
Leakage	26 (72.2)	19 (70.4)	7 (77.8)	
Spillage	10 (27.8)	8 (29.6)	2 (22.2)	
Frequency of incident (n=36), n (%)				Not examined
Less than one day per month	36 (100)	27 (100)	9 (100)	

[a] P value by Mann-Whitney U test, [b] P value by Fisher Exact test, [c] P value by Chi-Square test

4.2.1.4 Cultivated crops

Table 4.3 shows the type of crops currently grown or typically grown each year by the farmers and the mean number of harvests per year. In the study period, 15 different crops were cultivated. Eighty-three of the farmers grew rice only while the remaining farmers grew either vegetables or fruits. Most of the vegetable and fruit farmers practiced mixed crop farming which includes the production of multiple crops in the same field at any given time.

Corn was the main vegetable grown by the fruit/vegetable farmers, followed by okra, cucumber, gourd, chilli, long bean, kale, eggplant, pumpkin, sweet potato and tobacco. Watermelon was the main fruit grown by fruit/vegetable farmers, followed by bitter melon and soursop.

Table 4.3: Crops grown currently, per year and mean number of harvests per year

Crop	Current crop, n (%)	Crop grown per year, n (%)	Mean number harvest per year$\pm$SD (Min-Max)
Bitter melon	2 (1.3)	2 (1.3)	1.5$\pm$0.7 (1-2)
Chilli	11 (7.3)	12 (8.0)	2.3$\pm$2.5 (1-10)
Corn	29 (19.3)	32 (21.3)	2.5$\pm$0.8 (1-4)
Cucumber	20 (13.3)	29 (19.3)	2.0$\pm$0.9 (1-3)
Eggplant	7 (4.7)	8 (5.3)	2.1$\pm$1.1 (1-4)
Gourd	14 (9.3)	16 (10.7)	2.1$\pm$0.8 (1-4)
Kale	8 (5.3)	9 (6.0)	1.1$\pm$0.3 (1-2)
Long bean	9 (6.0)	10 (6.7)	2.7$\pm$0.8 (1-4)
Okra	23 (15.3)	32 (21.3)	2.1$\pm$0.8 (1-4)
Pumpkin	5 (3.3)	8 (5.3)	1.4$\pm$0.7 (1-3)
Rice	83 (55.3)	83 (55.3)	2.0$\pm$0.2 (1-2)
Soursop	1 (0.7)	1 (0.7)	1
Sweet potato	5 (3.3)	5 (3.3)	2.0$\pm$0.7 (1-3)
Tobacco	3 (2)	4 (2.7)	1.8$\pm$0.5 (1-2)
Watermelon	3 (2.0)	8 (5.3)	2.1$\pm$1.0 (1-3)

4.2.1.5 PPE used and clothes worn during previous spraying sessions

Table 4.4 shows PPE used and clothes worn by the farmers during previous spraying session. Out of 150 farmers, 76.0% of them used PPE and this percentage was similar between rice and vegetable/fruit farmers. The vegetable/fruit farmers wore chemical resistant boots more than rice farmers (p=0.04).

Table 4.4: PPE used and clothes worn during previous spraying session

Variable	Total (n=150)	Type of farming		
		Rice (n=83)	Vegetable/ Fruit (n=67)	P value
PPE used, n (%)				0.68 [a]
Yes	114 (76.0)	62 (74.7)	52 (77.6)	
No	36 (24.0)	21 (25.3)	15 (22.4)	
Clothes worn when pesticide sprayed, n (%)				
Hat	118 (78.7)	68 (81.9)	50 (74.6)	0.28 [a]
Goggle	7 (4.7)	3 (3.6)	4 (6.0)	0.70 [b]
Dusk mask	33 (22)	21 (25.3)	12 (17.9)	0.28 [a]
Face shield	11 (7.3)	8 (9.6)	3 (4.5)	0.35 [b]
Gloves	35 (23.3)	17 (20.5)	18 (26.9)	0.36 [a]
Long sleeve shirt	122 (81.3)	67 (80.7)	55 (82.1)	0.83 [a]
Shirt	36 (24.0)	19 (22.9)	17 (25.4)	0.72 [a]
Apron	1 (0.7)	1 (1.2)	0 (0.0)	1.00 [b]
Chemical resistant suit	6 (4.0)	5 (6.0)	1 (1.5)	0.23 [b]
Long trousers	140 (93.3)	77 (92.8)	63 (94)	1.00 [a]
Short	10 (6.7)	6 (7.2)	4 (6.0)	1.00 [b]
Chemical resistant boots	121 (80.7)	62 (74.7)	59 (88.1)	0.04 [a]
Shoes	19 (12.7)	9 (10.8)	10 (14.9)	0.46 [a]

[a] P value by Chi-Square test, [b] P value by Fisher Exact test

4.2.1.6 Part of body in contact with pesticides during previous spraying sessions

Table 4.5 shows the body parts that were in contact with pesticides during previous spraying sessions. Vegetable/fruit farmers reported being contaminated on their head (p= 0.02), back of torso (p<0.01), upper legs (p=0.04), lower legs (p<0.01) and feet (p <0.01) more than rice farmers.

Table 4.5: Body contact with pesticides during previous spraying session

Variable	Total (n=150)	Type of farming		
		Rice (n=83)	Vegetable /Fruit (n=67)	P value
Part of body in contact with pesticide, n (%)				
Head	50 (33.3)	21 (25.3)	29 (43.3)	0.02 [a]
Upper arms	1 (0.7)	0 (0.0)	1 (1.5)	0.45 [b]
Fore arms	37 (24.7)	17 (20.5)	20 (29.9)	0.19 [a]
Hands	117 (78.0)	66 (79.5)	51 (76.1)	0.62 [a]
Front of torso	11 (7.3)	7 (8.4)	4 (6.0)	0.76 [b]
Back of torso	26 (17.3)	7 (8.4)	19 (28.4)	<0.01 [a]
Upper legs	10 (6.7)	2 (2.4)	8 (11.9)	0.04 [b]
Lower legs	39 (26.0)	12 (14.5)	27 (40.3)	<0.01 [a]
Feet	54 (36.0)	22 (26.5)	32 (47.8)	<0.01 [a]

[a] P value by Chi-Square test, [b] P value by Fisher exact test

4.2.1.7 Post work hygienic behaviour of farmers during previous spraying sessions

Table 4.6 shows the washing and showering behaviours of the farmers during previous spraying sessions.

Table 4.6: Washing and showering behaviours during previous spraying session

Variable	Total (n=150)	Type of farming		
		Rice (n=83)	Vegetable/ Fruit(n=67)	P value [a]
Change into clean clothes, n (%)				0.16
Right away	146 (97.3)	81 (97.6)	65 (97)	
Later at the end of the day	2 (1.3)	2 (2.4)	0 (0.0)	
Next day or later in the week	2 (1.3)	0 (0.0)	2 (3.0)	
Shower after spraying pesticide, n (%)				1.00
Right away	146 (97.3)	81 (97.6)	65 (97.0)	
Later at the end of the day	4 (2.7)	2 (2.4)	2 (3.0)	
Wash hand/arm after spraying pesticide, n (%)				0.45
Right away	149 (99.3)	83 (100)	66 (98.5)	
Later at the end of the day	1 (0.7)	0 (0.0)	1 (1.5)	

[a] P value by Fisher Exact test

More than 95.0% of the farmers changed into clean clothes, showered and washed their hands/arms right away. There were no statistically significant differences in washing and showing behaviours of the rice and vegetable/fruit farmers.

Table 4.7 shows whether farmers repaired or cleaned equipment after spraying during previous spraying session. More vegetable/fruit farmers (98.5%) repaired equipment than rice farmers (41%: $p<0.01$).

However, 86.7% of the rice farmers washed or cleaned equipment compared to 70.1% of vegetable/ fruit farmers ($p=0.01$). Among those who washed equipment, more vegetable/fruit farmers always cleaned equipment ($p=0.01$) and used water and soap to clean the equipment ($p<0.01$).

4.2.1.8 Prevalence of pesticide used in first day of current spraying week

Table 4.8 shows the number of pesticides used on the first day of current spraying

Table 4.7: Repaired and cleaning equipment after spraying during previous spraying session

Variable	Total (n=150)	Type of farming		
		Rice (n=83)	Vegetable/ Fruit (n=67)	P value
Repair spraying or mixing equipment, n (%)				<0.01 [a]
Yes	100(66.7)	34 (41.0)	66 (98.5)	
No	50 (33.3)	49 (59.0)	1 (1.5)	
Clean equipment after pesticide use, n (%)				0.01 [b]
Yes	119 (79.3)	72 (86.7)	47 (70.1)	
No	31 (20.7)	11 (13.3)	20 (29.9)	
Frequency of cleaning spraying equipment (n=119), n (%)				0.01 [a]
Always	28 (23.5)	12 (16.7)	16 (34.0)	
Most of the times	19 (16.0)	8 (11.0)	11 (23.4)	
Half of the times	5 (4.2)	3 (4.2)	2 (4.3)	
Sometimes	67 (56.3)	49 (68.1)	18 (38.3)	
Place of cleaning spraying equipment (n=119), n (%)				0.18 [b]
Farm	89 (74.8)	57 (79.2)	32 (68.1)	
Home	30 (25.2)	15 (20.8)	15 (31.9)	
Activity when cleaning spraying equipment (n=119), n (%)				0.61 [a]
Hose down the sprayer	3 (2.5)	1 (1.4)	2 (4.3)	
Clean nozzle	3 (2.5)	2 (2.8)	1 (2.1)	
Rinse tank	113 (95.0)	69 (95.8)	44 (93.6)	
Material used to clean the equipment (n=119), n (%)				<0.01 [a]
Sand only	1 (0.8)	0 (0.0)	1 (2.1)	
Water only	102 (85.8)	69 (95.8)	33 (70.2)	
Water and soap	15 (12.6)	3 (4.2)	12 (25.5)	
Cleaning agent	1 (0.8)	0 (0.0)	1 (2.1)	

[a] P value by Fisher Exact test, [b] P value by Chi-Square test

week. More than half of the farmers used two or more types of pesticide. On average, two pesticides were used with a maximum of six pesticides used by the same individual. This can be observed especially among rice farmers. The vegetable/fruit farmers used a single type of pesticide more than rice farmers ($p<0.01$). The most frequently used type of pesticide was insecticides. 80.7% of the farmers used insecticides and more than 50.0% of them used a single type of insecticide. Rice farmers tended to use more insecticides than vegetable/fruit farmers ($p=0.02$).

Table 4.8: Pesticides used during first day of current spraying week

Pesticide used	Total (n=150)	Type of farming		
		Rice (n=83)	Vegetable/ Fruit (n=67)	P Value [a]
Number of pesticides used, n (%)				<0.01
1	62 (41.3)	19 (22.9)	43 (64.2)	
2	58 (38.7)	36 (43.4)	22 (32.8)	
3	18 (12.0)	16 (19.3)	2 (3.0)	
4	7 (4.7)	7 (8.4)	0 (0.0)	
5	1 (0.6)	1 (1.2)	0 (0.0)	
6	4 (2.7)	4 (4.8)	0 (0.0)	
Number of Insecticides used, n (%)				0.02
0	29 (19.3)	16 (19.3)	13 (19.4)	
1	71 (47.3)	31 (37.3)	40 (59.7)	
2	42 (28.1)	29 (34.9)	13 (19.4)	
3	8 (5.3)	7 (8.4)	1 (1.5)	
Number of Herbicides used, n (%)				<0.01
0	121 (80.7)	66 (79.5)	55 (82.1)	
1	21 (14.0)	9 (10.8)	12 (17.9)	
2	7 (4.7)	7 (8.5)	0 (0.0)	
4	1 (0.6)	1 (1.2)	0 (0.0)	
Number of Fungicides used, n (%)				<0.01
0	97 (64.7)	41 (49.5)	56 (83.6)	
1	39 (26.0)	29 (34.9)	10 (14.9)	
2	10 (6.6)	9 (10.8)	1 (1.5)	
3	4 (2.7)	4 (4.8)	0 (0.0)	

[a] P value by Fisher Exact test

19.3% of the farmers used herbicides and all vegetable and fruit farmers used a single type of herbicide. 35.3% of the farmers used fungicides and the majority of them used a single type of fungicide. Rice farmers tended to use more herbicides and fungicides than vegetable/fruit farmers ($p<0.01$).

Table 4.9 lists the pesticides used by the farmers during first day during spraying week. More than 20 different types of classes of pesticides were used including carbamates OPs, pyrethroids, azoles and macrocyclic lactones. The use of tricylazone ($p<0.01$), isoprothiolane ($p=0.02$), chlorpyrifos/cypermethrin ($p=0.01$), fentin acetate ($p=0.03$), lambda cyhalothion ($p<0.01$), chlorantraniliprole ($p<0.01$) and pymetrozine ($p=0.03$) was more common among rice farmers than vegetable/fruit farmers. Meanwhile, the use of flubendiamide ($p<0.01$), paraquat dichloride ($p<0.01$), abamectin ($p<0.01$), imidacloprid ($p<0.01$) was more common among vegetable/fruit farmers than rice farmers.

Table 4.9: Pesticides used by the farmers on first day of spraying week

Chemical family /Mode of action	Active ingredient	Pesticide type (Activity)	Total (n =150)	Type of farming		
				Rice (n= 83)	Vegetable/ Fruit (n =67)	P value [a]
Alpha-chloroacetamides (Inhibition of very long chain fatty acid synthesis Group:15)	Pretilachlor	Herbicide	1 (0.7)	1 (1.2)	0 (0.0)	1.00
Amides (Inhibition of photosynthesis at PS-II-Serine 264 binders- Group:5)	Propanil	Herbicide	2 (1.3)	2 (2.4)	0 (0.0)	0.50
Alpha-chloroacetamides (Inhibition of very long chain fatty acid synthesis-Group:15)/ Pyrimidinyl benzoates (Inhibition of acetolactate synthase- Group:2)	Pretilachlor/Pyribenzoxim	Herbicide	1 (0.7)	1 (1.2)	0 (0.0)	1.00
Acylananine (Disrupt nucleic acid synthesis) /Carbamate Mancozeb (Unknown MoA)	Metalaxy/Mancozeb	Fungicide	1 (0.7)	1 (1.2)	0 (0.0)	1.00
Methoxy-acrylate (Inhibition of quinone outside- Group 3C)	Azoxystrobin	Fungicide	1 (0.7)	1 (1.2)	0 (0.0)	1.00
Methoxy-acrylate (Inhibition of quinone outside- Group 3C)/ Triazoles (Demethylation inhibitor –Group 1G)	Azoxystrobin/ Difenoconazole	Fungicide	8 (5.3)	6 (7.2)	2 (3.0)	0.30
Benzimidazole (Inhibition of cytoskeleton and motor protein- Group 1B)	Carbendazim	Fungicide	5 (3.3)	4 (4.8)	1 (1.5)	0.38
Triazoles (Demethylation inhibitor –Group 1G)	Difenoconazole Epoxiconazole Tricyclazone	Fungicide Fungicide Fungicide	2 (1.3) 1 (0.7) 9 (6.0)	1 (1.2) 1 (1.2) 9 (10.8)	1 (1.5) 0 (0.0) 0 (0.0)	1.00 1.00 <0.01
Benzoylureas (Inhibitors of chitin biosynthesis affectinmg CHS 1- Group 15)	Flufenoxuron Lufenuron	Insecticide Insecticide	4 (2.7) 2 (1.3)	0 (0.0) 1 (1.2)	4 (6.0) 1 (1.5)	0.04 1.00
Carbamate (Inhibitor of Acetylcholinesterase- Group 1A)	Flubendiamide Formetanate Mancozeb Pyraclostrobin Propamocard hydrochloride	Insecticide Insecticide Fungicide Fungicide Fungicide	19 (12.7) 1 (0.7) 9 (6.0) 1 (0.7) 1 (0.7)	18 (21.7) 0 (0.0) 5 (6.0) 1 (1.2) 0 (0.0)	1 (1.5) 1 (1.5) 4 (6.0) 0 (0.0) 1 (1.5)	<0.01 0.45 1.00 1.00 0.45

	Propineb	Fungicide	10 (6.7)	8 (9.6)	2 (3.0)	0.19
Carbamate (Inhibitor of Acetylcholinesterase- Group 1A)/ Benzimidazole (Inhibition of cytoskeleton and motor protein- Group 1B)	Mancozeb/Carbendazim	Fungicide	3 (2.0)	3 (3.6)	0 (0.0)	0.25
Pyridinium (PS I electrone diversion- Group 22)	Paraquat Dichloride	Herbicide	11 (7.3)	0 (0.0)	11 (16.4)	<0.01
Avermectin (Allosteric modulator for Glutamate-gated chloride channel- Group 6)	Abamectin	Insecticide	10 (6.7)	0 (0.0)	10 (14.9)	<0.01
Phosphorothiolate (Inhibitor for phospholipid biosynthesis- Group 6)	Isoprothiolane	Fungicide	7 (4.7)	7 (8.4)	0 (0.0)	0.02
Bacillus thuringiensis (Microbial distruptos of insect midgut membranes- Group 11A)	Bacillus Thuringiensis	Insecticide	3 (2.0)	0 (0.0)	3 (4.5)	0.09
Neonicotiniods (Competative modulators for nicotinic acetylcholine receptor (nAChR)- Group 4A)	Imidacloprid Acetamiprid	Insecticide Insecticide	9 (6.0) 1 (0.7)	0 (0.0) 0 (0.0)	9 (13.4) 1 (1.5)	<0.01 0.45
Neonicotiniods (Competative modulators for nicotinic acetylcholine receptor (nAChR)- Group 4A)/ Pyrethroid (Modulator for sodium channel-Group 3A)	Imidacloprid/Beta-Cyfluthrin	Insecticide	1 (0.7)	0 (0.0)	1 (1.5)	0.45
Neonicotinoid/Diamine (Modulator for ryanodine recepotor-Group 28)	Thiamethoxam/Chloraniliprole	Insecticide	6 (4.0)	4 (4.8)	2 (3.0)	1.00
Nereistoxin analogues (Blocker of nicotinic acetylcholine receptor- Group 14)	Cartap hydrochloride	Insecticide	1 (0.7)	1 (1.2)	0 (0.0)	1.00
Aryloxyphenoxy-propionates (Inhibition of acetyl coa carboxylase- Group 1)	Fenoxaprop ethyl	Herbicide	2 (1.3)	2 (2.4)	0 (0.0)	0.50
Benzoylurea (Inhibition of chitin biosynthesis affecting CHS 1- Group 15)	Chlorfluazuron	Insecticide	1 (0.7)	0 (0.0)	1 (1.5)	0.45
METI acaricide (Inhibitors for mitochondrial complex I electron transport – Group 21A)	Pyridaben	Insecticide	1 (0.7)	0 (0.0)	1 (1.5)	0.45
Organophosphate (Inhibition of Acetylcholinesterase- Group 1B)	Chlorpyrifos Dimethoate	Insecticide Insecticide	10 (6.7) 3 (2.0)	5 (6.0) 0 (0.0)	5 (7.5) 3 (4.5)	1.00 0.09

	Fenthion Glyphosate isopropylamine Malathion	Insecticide Herbicide Insecticide	1 (0.7) 2 (1.3) 2 (1.3)	1 (1.2) 1 (1.2) 0 (0.0)	0 (0.0) 1 (1.5) 2 (3.0)	1.00 1.00 0.20
Organophosphate/Carbamate Organophosphate (Inhibition of Acetylcholinesterase- Group 1B)	Fenitrothion/Fenobucarb	Insecticide	2 (1.3)	2 (2.4)	0 (0.0)	0.50
Organophosphate (Inhibition of Acetylcholinesterase- Group 1B) / Pyrethroid (Modulator for sodium channel- Group 3A)	Chlorpyrifos/Cypermethrin	Insecticide	15 (10.0)	13 (15.7)	2 (3.0)	0.01
Triphenyltin (Inhibion of oxidative phosphorylation ATP synathase- Group 6C)	Fentin acetate	Fungicide	6 (4.0)	6 (7.2)	0 (0.0)	0.03
Isoxazolidinone (Inhibition of deoxy-d-xyulose phosphate synthase -Group:13)/ Amides (Inhibition of photosynthesis at PS-II-Serine 264 binders- Group:5)	Clomazone /Propanil	Herbicide	1 (0.7)	1 (1.2)	0 (0.0)	1.00
Phenoxy-carboxylates (Auxin mimics- Group 4)	2,4-Butyester 2,4-D-dimethylammonium 2,4-D-Iso-butyl ester MCPA Dimethylammonium MCPA Potassium	Herbicide Herbicide Herbicide Herbicide Herbicide	1 (0.7) 1 (0.7) 2 (1.3) 1 (0.7) 4 (2.7)	1 (1.2) 1 (1.2) 2 (2.4) 1 (1.2) 4 (4.8)	0 (0.0) 0 (0.0) 0 (0.0) 0 (0.0) 0 (0.0)	1.00 1.00 0.50 1.00 0.13
Phenylpyrazole (Blockers of GABA-gated chloride channel- Group 2B)	Fipronil	Insecticide	4 (2.7)	1 (1.2)	3 (4.5)	0.33
Phenylpyrazole (Blockers of GABA-gated chloride channel- Group 2B)/ Neonicotiniods (Competative modulators for nicotinic acetylcholine receptor (nAChR)- Group 4A)	Fipronil/Imidacloprid	Insecticide	1 (0.7)	0 (0)	1 (1.5)	0.45
Pyrethroid (Modulator for sodium channel- Group 3A)	Cypermetrin Deltamethrin Lambda cyhalothin	Insecticide Insecticide Insecticide	13 (8.7) 6 (4.0) 11 (7.3)	8 (9.6) 5 (6.0) 11 (13.3)	5 (7.5) 1 (1.5) 0 (0.0)	0.77 0.23 <0.01
Quinoline-carboxylates (Auxin mimics- Group 4)	Quinclorac	Herbicide	3 (2.0)	3 (3.6)	0 (0.0)	0.25
Diamide (Modulator for ryanodine	Chlorantraniliprole	Insecticide	36 (24.0)	27 (32.5)	9 (13.4)	<0.01

receptor-Group 28)						
Strobilurin (Respiration inhibition) / Triazoles (Demethylation inhibitor –Group 1G)	Trifloxystrobin/Tebuconazole	Fungicide	3 (2.0)	2 (2.4)	1 (1.5)	1.00
Sulfonylurea (Inhibition of acetolactate synthase -Group 2)	Bensulfuron-Methyl Chlorimuron-Ethyl Metsulfuron –Methyl	Herbicide Herbicide Herbicide	1 (0.7) 1 (0.7) 2 (1.3)	1 (1.2) 1 (1.2) 2 (2.4)	0 (0.0) 0 (0.0) 0 (0.0)	1.00 1.00 0.50
Sulfonylurea (Inhibition of acetolactate synthase -Group 2) / Quinoline-carboxylates (Auxin mimics-Group 4)	Bensulfuron-methyl/ Quinolorac	Herbicide	1 (0.7)	1 (1.2)	0 (0.0)	1.00
Sulfonylurea (Inhibition of acetolactate synthase -Group 2)	Metsulfuron-Methyl/Bensulfuron methyl	Herbicide	1 (0.7)	1 (1.2)	0 (0.0)	1.00
Buprofezin (Inhibition of chitin biosynthesis, type 1- Group 16)	Bentazone Buprofezin	Herbicide Insecticide	1 (0.7) 4 (2.7)	1 (1.2) 4 (4.8)	0 (0.0) 0 (0.0)	1.00 0.13
Buprofezin (Inhibition of chitin biosynthesis, type 1- Group 16)/ Nereistoxin analogues (Blocker of nicotinic acetylcholine receptor- Group 14)	Buprofezin/Cartap hydrochloride	Insecticide	2 (1.3)	2 (2.4)	0 (0.0)	0.50
Pyridine azomethine (Modulator for chordotonal organ TRPV channel- Group 9B)	Pymetrozine	Insecticide	6 (4.0)	6 (7.2)	0 (0.0)	0.03
Triazoles (Demethylation inhibitor –Group 1G)/ Triazoles (Demethylation inhibitor –Group 1G)	Difenononazol/Propiconazol	Fungicide	4 (2.7)	4 (4.8)	0 (0.0)	0.13
Diafenthiuron (Inhibors of mitochondrial ATP synthase- Group 12A)	Diafenthiuron	Insecticide	2 (1.3)	0 (0.0)	2 (3.0)	0.20
White oil (UNE)	White oil	Insecticide	1 (0.7)	0 (0.0)	1 (1.5)	0.45
Illegal pesticide	Illegal pesticide	Insecticide	1 (0.7)	1 (1.2)	0 (0.0)	1.00

[a] P value by Fisher Exact test, Adapted from (173,174)

4.2.2 Pesticide Exposure Assessment

4.2.2.1 Pesticide exposure intensity scores based on algorithm from AHS and EFS

Figure 4.2 show the distribution of pesticide exposure intensity scores calculated using the AHS and EFS algorithms. Both pesticide exposure intensity scores were not normally distributed. The median (Q1-Q3) exposure level was 151.1 (107.8-151.1) and 2.0 (1.9-2.4) based on EFS and AHS study, respectively.

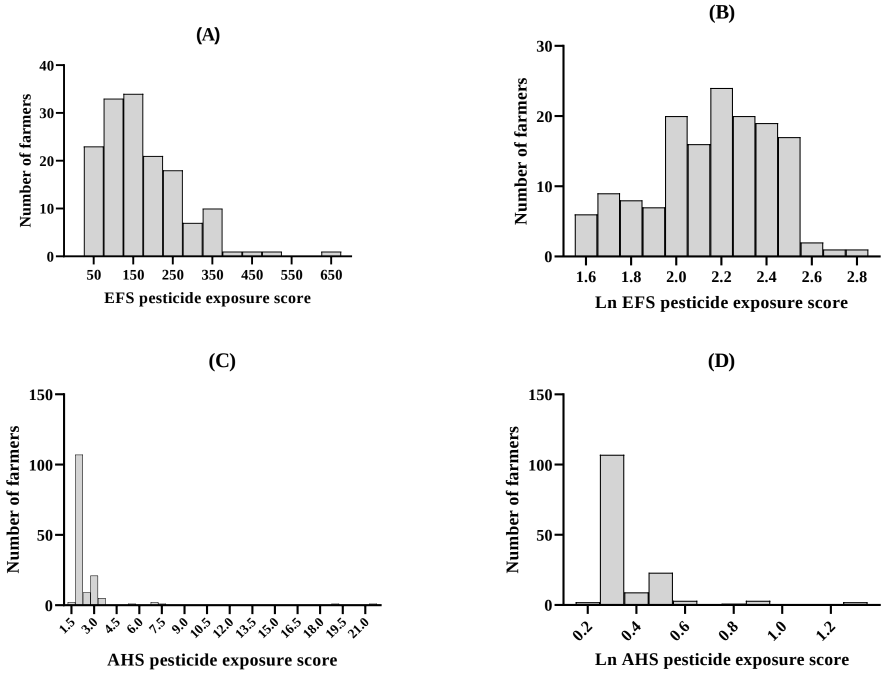


Figure 4.2: The distribution for EFS and AHS pesticide exposure intensity score
(A) EFS pesticide exposure intensity score, (B) Ln EFS pesticide exposure intensity score, (C) AHS pesticide exposure intensity score, and (D) Ln AHS pesticide exposure intensity score
*Scale of Y axis is different between graph

Table 4.10 shows the median and Q1-Q3 of semi-quantitative exposure scores using the EFS and AHS algorithms based on type of farming. The median EFS semi-quantitative exposure score was higher among rice farmers compared to vegetable/fruit farmers ($p<0.01$). However, the median AHS semi-quantitative exposure score was similar for both types of farms.

Table 4.10: Level of semi-quantitative pesticide exposure scores based on EFS and AHS among the farmers

Farm type	EFS		AHS	
	Median (Q1-Q3)	P value [a]	Median (Q1-Q3)	P value [a]
Rice	173.1 (115.4-239.6)	< 0.01	2.0 (1.9-2.9)	0.4
Vegetable/fruit	125.1 (125.1-217.8)		2.0 (1.9-2.0)	

[a] P value by Mann-Whitney U test

4.2.2.2 Quantification of dermal exposure using DREAM

4.2.2.2.1 Validation of DREAM Scores results between main researcher and expert panels

Ten videos of five farmers doing mixing and spraying were chosen randomly. The main researcher and expert panel observed the videos and completed DREAM questionnaire checklist. Table 4.11 shows the results of DREAM scores category between main researchers and three experts. The ICC for inter rater reliability was excellent being 0.85 with 95% CI (0.61,0.96). The ICC'S for intra rater reliability between main researcher and expert 1,2 and 3 were between good and excellent with ICC and 95% CI of 0.86 (0.43,0.97), 0.77 (0.08,0.94) and 0.80 (0.26,0.95), respectively.

4.2.2.2.2 DREAM scores

Shown in Figure 4.3 is the distribution of total DREAM scores among the farmers. The median (Q1-Q3) DREAM scores of all the farmers was 74.1 (40.0-102.2).

Table 4.12 shows the DREAM scores during mixing, spraying and body parts involved among the farmers. During mixing, the hands of vegetable/fruit farmers were exposed more with a median score (Q1-Q3) of 27.0 (2.5-48.6) compared to rice farmers with a median score (Q1-Q3) of 2.6 (0.9-10.4) (p<0.01). Vegetable/fruit farmers had higher DREAM scores with a median (Q1-Q3) of 27.0 (2.6-53.3) compared to rice farmers with a median (Q1-Q3) of 2.7 (0.9-11.9) (p<0.01).

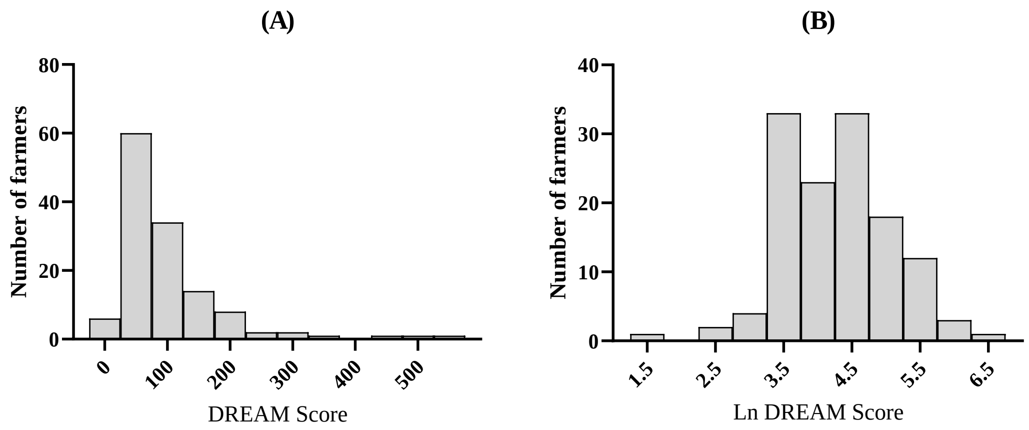


Figure 4.3: The distribution of total DREAM Scores among the farmers
(A) DREAM Score, and (B) Ln DREAM score
*Scale of Y axis is difference between graphs

Figure 4.4 shows the DREAM scores for other parts of body during mixing among the farmers. During mixing, the median (Q1-Q3) score of DREAM was 0 for body exposure. This is because 88.5% (n=69) and 87.0% (n=47) of the rice and vegetable/fruit farmers, respectively had 0 DREAM body scores.

However, during spraying, the bodies of rice farmers was exposed more with a median score (Q1-Q3) of 57.0 (36.0-111.0) compared to vegetable/fruit farmers with a median score (Q1-Q3) of 36.2 (36.0-92.1) (p=0.01). Rice farmers then had higher DREAM scores with a median (Q1-Q3) of 58.6 (36.0-111.0) compared to vegetable/fruit farmers with median (Q1-Q3) of 36.2 (36.0-94.8) (p<0.01).

Figure 4.5 shows the DREAM scores for hands during spraying among the farmers. During spraying, the median (Q1-Q3) score of DREAM for hands for all farmers was 0. This is because 68.8% (n=53) and 81.1% (n=43) of the rice and vegetable/fruit farmers, respectively had 0 DREAM scores.

During both activities, the hands of vegetable/fruit farmers were exposed more with a median score (Q1-Q3) of 27.0 (3.2-48.6) compared to rice farmers with a median score (Q1-Q3) of 4.1 (0.9-15.9). However, the bodies of rice farmers were exposed more with median (Q1-Q3) of 57.0 (36.0-111.0) compared to vegetable/fruit

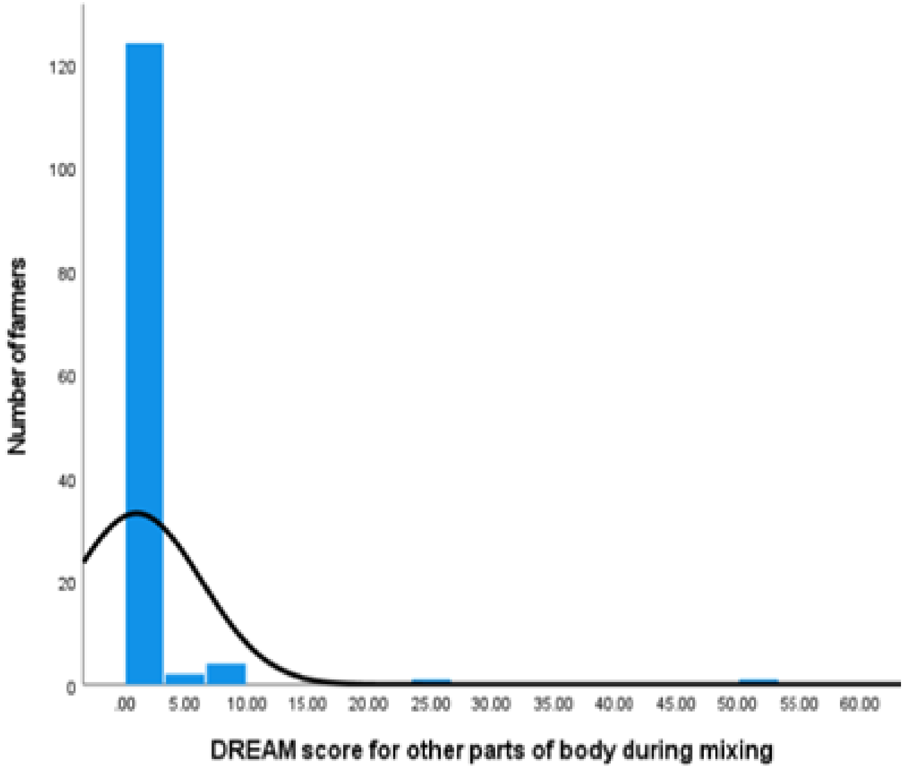


Figure 4.4: The DREAM Scores for other parts of body during mixing among the farmers

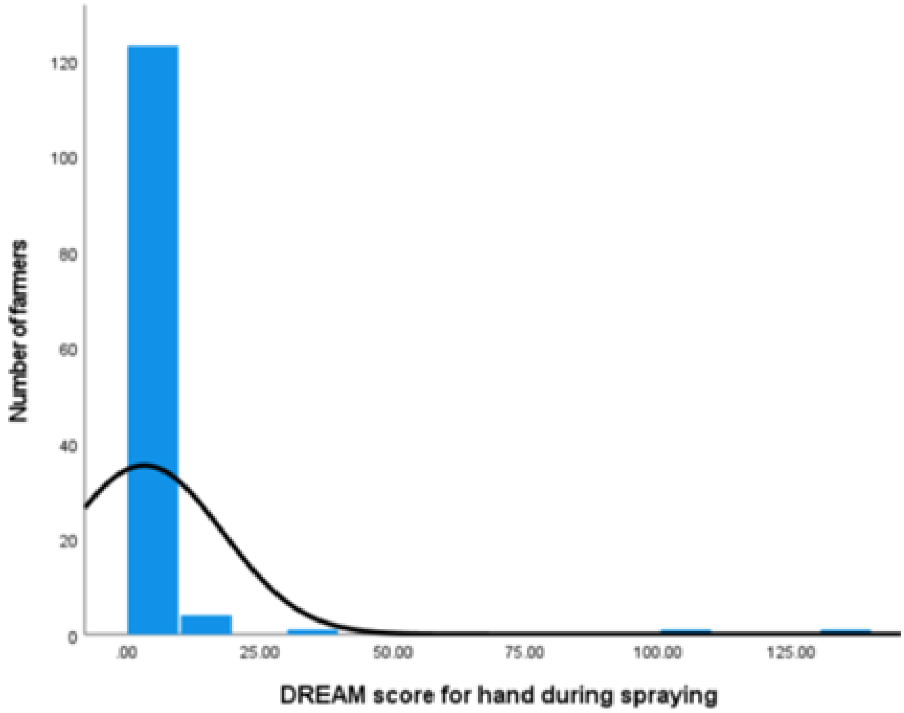


Figure 4.5: The DREAM Scores for hands during spraying among the farmers

farmers with median (Q1-Q3) of 36.3 (36.0-66.5) (p=0.03). The total dermal exposure score was found to be highest among rice farmers with a median (Q1-Q3) of 77.1 (39.0-116.7) and lowest among vegetable/fruit farmers with a median (Q1-Q3) of 64.7 (41.0-125.9) but the difference was not statistically significant (p=0.89).

4.2.2.3 Level of urine metabolites of the farmers

4.2.2.3.1 Frequency of urine samples containing detectable urinary metabolites

Urines from farmers who reported using biferenthin, chlorphyrifos, pyrethroids or cypermethrin were analysed as discussed in Section 2.5.3. In total, 51 urine samples from 26 farmers were analysed, consisting of 25 post-spraying urine samples and 26 pre-spraying urine samples. One pre-spraying sample container was broken and the sample could not be analysed.

Figure 4.6 shows the percentage of urine samples that were positive for each pesticide/pesticide metabolite pre-and post-spraying. The percentage of urine samples that contained detectable levels of bifenthrin, 3PBA, DBVA, cDCVA, tDCVA and total DCVA were higher post-spraying compared to pre-spraying except for 356TCP where the percentage was similar between pre- and post-spraying. 356TCP was the most frequently detected metabolite and was detected in all urine samples both pre- and post-spraying. tDCVA and total DCVA were detected in 84.6% (22/26) of pre- and 96.0% (24/25) of post-spraying samples. For PBA, the proportion of positive urine samples was 84.6% (22/26) and 88.0% (22/25) for pre-and post-spraying samples respectively.

DBVA was detected in 19.2% (5/26) of pre- and 24.0% (6/25) of post-spraying samples and cDCVA was detected in 61.5% (16/26) of pre- and 88.0% (22/25) of post-spraying samples. Bifenthrin was detected in 53.8% (14/26) of pre- and 80.0% (20/25) of post-spraying samples. However, there was no significant difference between the percentage of urines with detectable metabolites pre-and post-spraying and type of farming (Data not shown).

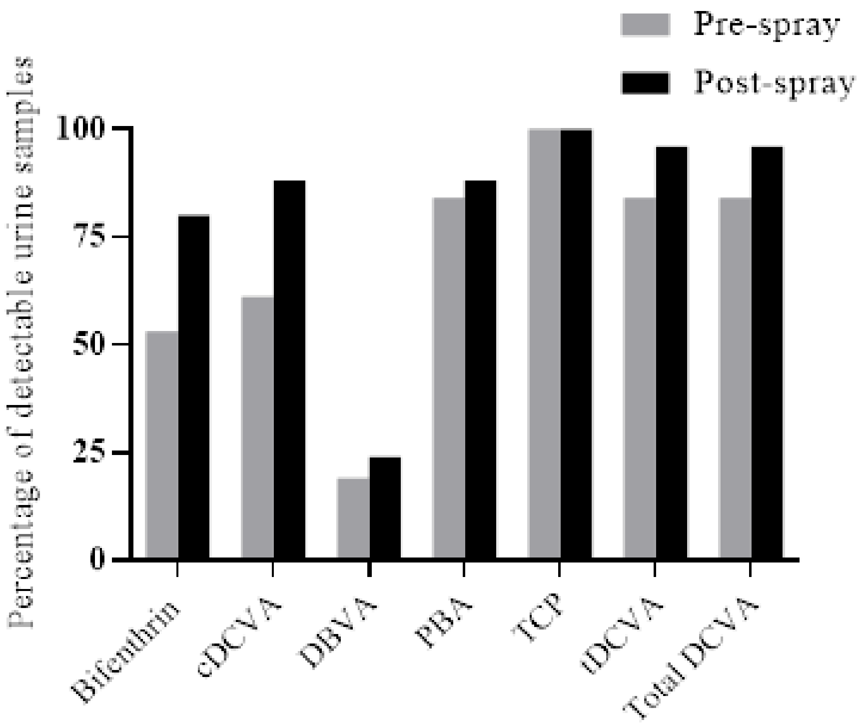


Figure 4.6: Percentage of detectable urine metabolites

4.2.2.3.2 Urinary metabolites among farmers who reported using or not using pesticides

Table 4.13 shows the levels of pre- and post-spraying urinary pesticide metabolites adjusted by urinary creatinine levels. The concentration of the metabolites varied depending upon whether the farmer used the specific type of pesticide or not.

For farmers who reported using the specific pesticide, urine levels post-spraying were higher than urine levels pre-spraying for chlorpyrifos ($p<0.01$), pyrethroids ($p<0.01$) and cypermethrin ($p<0.01$). However, for farmers who had not used the specific pesticide, there was no significant difference between pre- and post-spray samples.

For farmers who reported using the specific pesticide, urine levels pre-spraying were higher for chlorpyrifos ($p<0.01$) and cypermethrin ($p=0.02$) compared to those farmers who had not used the specific pesticide (Data not shown). For farmers who did not reported using the specific pesticide, urine levels post-spraying was higher for cypermethrin (p=0.02) to those farmers who had not used specific pesticide (Data not shown).

For farmers who reported using the specific pesticide, the difference in urine levels post- and pre-spraying was higher for chlorpyrifos (p=0.02), pyrethroid (p=0.03) and cypermethrin (p=0.02) than for those farmers who had not used the specific pesticide.

4.2.3 Associations between pesticide exposure and demographics and working practices

4.2.3.1 EFS and AHS pesticide exposure intensity scores and demographics

There was no association between EFS and AHS pesticide exposure intensity scores and demographic factors (Table 4.14).

4.2.3.2 DREAM scores and demographics

Table 4.15 shows the associations between DREAM scores and demographic factors. The farmers who come from lower income families had higher DREAM scores compared to the farmers who came from middle income families (p=0.03).

4.2.3.3 Correlations between AHS and EFS pesticide exposure intensity scores and DREAM scores

Figure 4.7 shows the associations between AHS and EFS pesticide exposure intensity scores and DREAM scores. The correlation revealed a moderate significant positive linear correlation between EFS and AHS pesticide exposure intensity score ($p<0.01$). However, no significant association was found between DREAM and pesticide exposure intensity scores.

Table 4.11: Results of DREAM scores between main researcher and 3 expert panels

Raters	Farmer 1		Farmer 2		Farmer 3		Farmer 4		Farmer 5	
	Mixing	Spraying	Mixing	Spraying	Mixing	Spraying	Mixing	Spraying	Mixing	Spraying
Main researcher	157	5	106	52	194	225	5	2	15	70
Expert 1	179	16	85	16	408	167	17	6	9	24
Expert 2	380	48	14	97	369	138	1	6	13	30
Expert 3	159	85	194	23	183	570	52	83	7	59

Table 4.12: DREAM scores during mixing and spraying and body parts involved among the farmers

Type of activity	Hands			Body [a]			Total [b]		
	Rice, Median(Q1-Q3)	Vegetable/Fruit, Median(Q1-Q3)	P value [c]	Rice, Median(Q1-Q3)	Vegetable/Fruit, Median (Q1-Q3)	P value [c]	Rice, Median (Q1-Q3)	Vegetable/Fruit, Median (Q1-Q3)	P value [c]
Mixing	2.6 (0.9-10.4)	27.0 (2.5-48.6)	<0.01	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.71	2.7 (0.9-11.9)	27.0 (2.6-53.3)	<0.01
Spraying	0.0 (0.0-1.6)	0.0 (0.0-0.0)	0.20	57.0 (36.0-111.0)	36.2 (36.0-92.1)	0.01	58.6 (36.0-111.0)	36.2 (36.0-94.8)	<0.01
Total	4.1 (0.9-15.9)	27.0 (3.2-48.6)	<0.01	57.0 (36.0-111.0)	36.3 (36.0-66.5)	0.03	77.1 (39.0-116.7)	64.7 (41.0-125.9)	0.89

[a] Involved head, upper arms, forearms, torso front, torso back, lower back, lower leg and feet , [b] Combination of hands and body , [c] P value by using Mann- Whitney U test

Table 4.13: Urinary pesticide metabolites concentrations adjusted by urinary creatinine among farmers who used and not used specific pesticide

Pesticide/ Metabolite [a]	Exposure	Farmers who had used specific pesticide			Farmers who had not used specific pesticide		
		Median (Q1-Q3) mmol/mole creatinine; n			Median (Q1-Q3) mmol/mole creatinine; n		
		Post-spray Median (Q1-Q3); n	Pre-spray Median (Q1-Q3); n	Δ(Post-spray-pre-spray)	Post-spray Median (Q1-Q3); n	Pre-spray Median (Q1-Q3); n	Δ(Post-spray-pre-spray)
Bifenthrin	Pyrethroid	0.7 (0.4-2.5); 22	0.4 (0.0-1.1); 21 [b]	0.4 (-0.2-1.3); 21	0.0 (0.0-3.5); 4	0.2 (0.0-0.6); 4 [b]	0.0 (-0.3-2.9); 4 [d]
cDCVA	Cypermethrin	2.2 (0.9-4.1); 18	0.8 (0.3-1.6); 18 [c]	1.4 (0.5-3.1); 18	0.5 (0.0-0.6); 8	0.0 (0.0-0.3); 8 [b]	0.3 (0.0-0.6); 8 [e]
DBVA	Deltamethrin	0.0 (0.0-0.2); 4	0.0 (0.0-0.0); 4 [b]	0.0 (0.0-0.4); 4	0.0 (0.0-0.8); 22	0.0 (0.0-0.4); 22 [b]	0.0 (0.0-0.0); 22 [d]
3PBA	Pyrethroid	1.8 (0.6-3.7); 22	0.9 (0.5-1.7); 21 [c]	0.5 (0.1-2.0); 21	0.5 (0.0-1.1); 4	0.5 (0.1-2.3); 4 [b]	-0.2 (-1.3-0.2); 4 [e]
356TCP	Chlorpyrifos	94.0 (18.6-228.4); 16	43.0 (18.8-121.5); 17 [c]	11.0 (1.8-130.5); 16	4.6 (2.7-8.1); 9	6.3 (3.6-9.8); 9 [b]	-0.4 (-1.9-4.2); 9 [e]
tDCVA	Cypermethrin	3.5 (1.5-5.9); 18	1.5 (0.8-1.6); 18 [c]	2.1 (0.5-3.5); 18	0.8 (0.4-1.1); 8	0.5 (0.1-0.7); 8 (0.45) [b]	0.2 (-0.5-0.8); 8 [e]
Total DCVA	Cypermethrin	5.6 (2.3-10.3); 18	1.9 (1.4-4.2); 18 [c]	3.5 (1.0-6.7); 18	1.3 (0.4-1.7); 8	0.7 (0.1-0.7); 8 (0.29) [b]	0.6 (-0.5-1.3); 8 [e]

[a] Urinary metabolite level expressed as µmol/mole creatinine, [b] P value >0.05 by using Wilcoxin Signed Rank Test difference between post- and pre-spray level in farmers who used pesticide or did not used pesticide, [c] P value <0.01 by using Wilcoxin Signed Rank Test difference between post- and pre-spray level in farmers who used pesticide or did not used pesticide, [d] P value ≥0.05 by Mann-Whitney U test difference in post- and pre-spray level between farmers who used and did not used pesticide, [e] P value <0.05 by Mann-Whitney U test difference in post- and pre-spray level between farmers who used and did not used pesticide.

Table 4.14: Associations between EFS and AHS pesticide exposure intensity scores and demographic factors

Variable	EFS Median (Q1-Q3)	P value	AHS Median (Q1-Q3)	P value
Age	-0.13 [a]	0.13 [b]	0.01 [a]	0.33 [b]
BMI		0.28 [c]		0.63 [c]
Under weight	189.3 (106.8-287.2)		2.4 (2.3-3.7)	
Normal weight	156.7 (110.0-217.8)		2.4 (2.3-2.8)	
Overweight	129.9 (62.6-244.9)		2.4 (2.4-2.5)	
Obesity	111.4 (94.2-221.9)		2.4 (2.4-3.6)	
Marital status		0.23 [c]		0.62 [c]
Single	174.2 (100.8-272.0)		2.4 (2.3-3.6)	
Married	151.1 (108.9-224.3)		2.4 (2.4-2.8)	
Widower	85.7 (62.6-85.7)		2.3 (2.2-2.3)	
Educational level		0.45 [c]		0.55 [c]
Never been to school	152.3 (107.8- 152.3)		2.4 (2.3-2.6)	
Primary education	160.9 (108.9-246.9)		2.4 (2.4-3.7)	
Secondary education	151.1 (104.6-217.8)		2.4 (2.4-2.8)	
Tertiary education	123.2 (53.4-228.5)		2.4 (2.4-2.4)	
Income per month		0.18 [d]		0.27 [d]
Lower income	160.9 (108.9-251.9)		2.4 (2.4-3.0)	
Middle income	139.9 (103.8-205.6)		2.4 (2.3-2.5)	
Smoking status		0.31 [d]		0.11 [d]
Current/ex-smokers	159.8 (108.9-239.6)		2.4 (2.3-2.5)	
Non smokers	133.2 (97.1-226.3)		2.4 (2.4-3.2)	

[a] Correlation coefficient, [b] P value by Spearman rank test, [c] P value by Kruskal Wallis test, [d] P value by Mann-Whitney U test

Table 4.15: Associations between DREAM scores and demographic factors

Variable	DREAM scores Median (Q1-Q3)	P value
Age	-0.01 [a]	0.99 [b]
BMI		0.17 [c]
Under weight	95.4 (60.8-147.8)	
Normal weight	60.9 (38.6-112.8)	
Overweight	80.9 (48.7-139.4)	
Obesity	106.8 (60.1-192.0)	
Marital status		0.42 [c]
Single	95.6 (56.3-122.0)	
Married	67.8 (38.7-122.5)	
Widower	168.3 (55.7-168.3)	
Educational level		0.63 [c]
Never been to school	107.0 (85.9-138.4)	
Primary education	92.4 (38.4-136.1)	
Secondary education	65.3 (41.0-112.2)	
Tertiary education	63.3 (337.7-116.3)	

Income per month		0.03 [d]
Lower income	90.5 (45.1-130.1)	
Middle income	59.5 (38.1-110.7)	
Smoking status		0.44 [d]
Current/ex-smokers	75.0 (41.0-128.8)	
Non smokers	63.3 (38.5-113.5)	

[a] Correlation coefficient, [b] P value by Spearman rank test, [c] P value by Kruskal Wallis test, [d] P value by Mann- Whitney U test

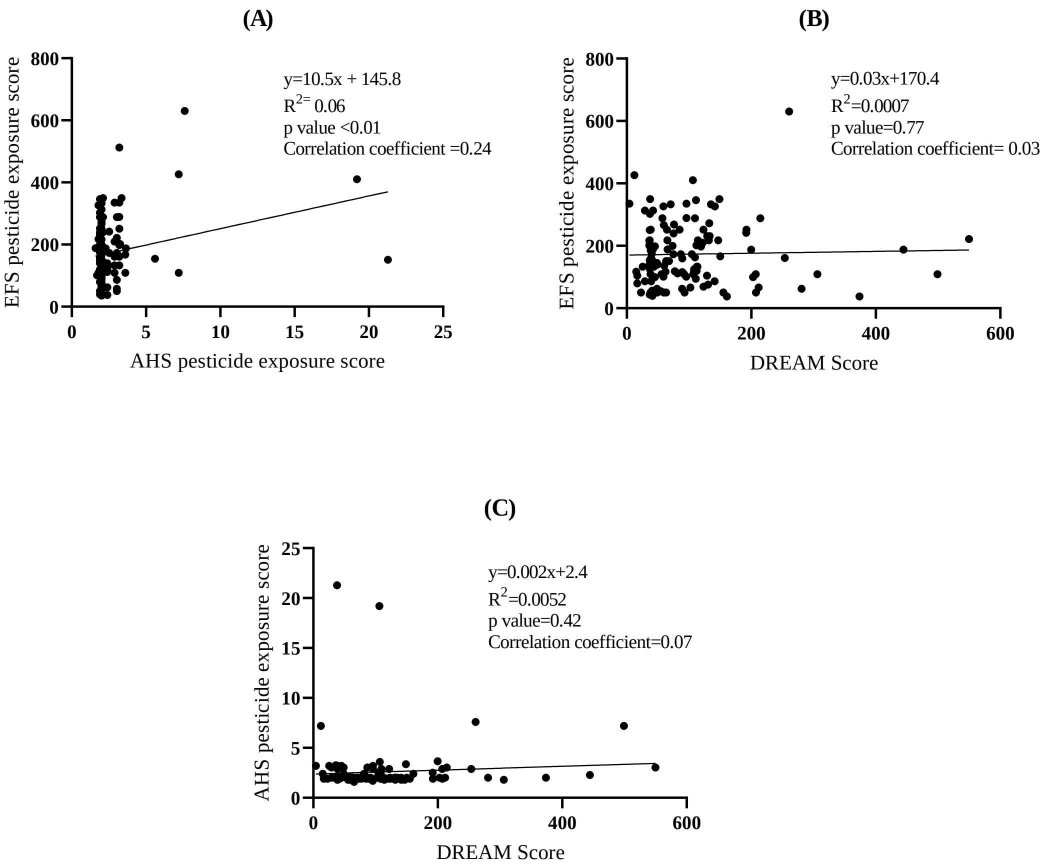


Figure 4.7: Correlations between AHS, EFS pesticide exposure intensity scores and DREAM scores (A) Scatter plot of AHS and EFS pesticide exposure intensity score, (B) Scatter plot of DREAM Scores sand EFS pesticide exposure intensity score, and (C) Scatter plot of DREAM Scores and AHS pesticide exposure intensity score

Figure 4.8 shows the correlations between Ln AHS, Ln EFS pesticide exposure intensity scores and Ln DREAM scores. The correlation revealed a weak significant positive linear correlation between EFS and AHS pesticide exposure intensity score ($p<0.01$). This is driven by two scores for AHS which were 1.33 and 1. 28.

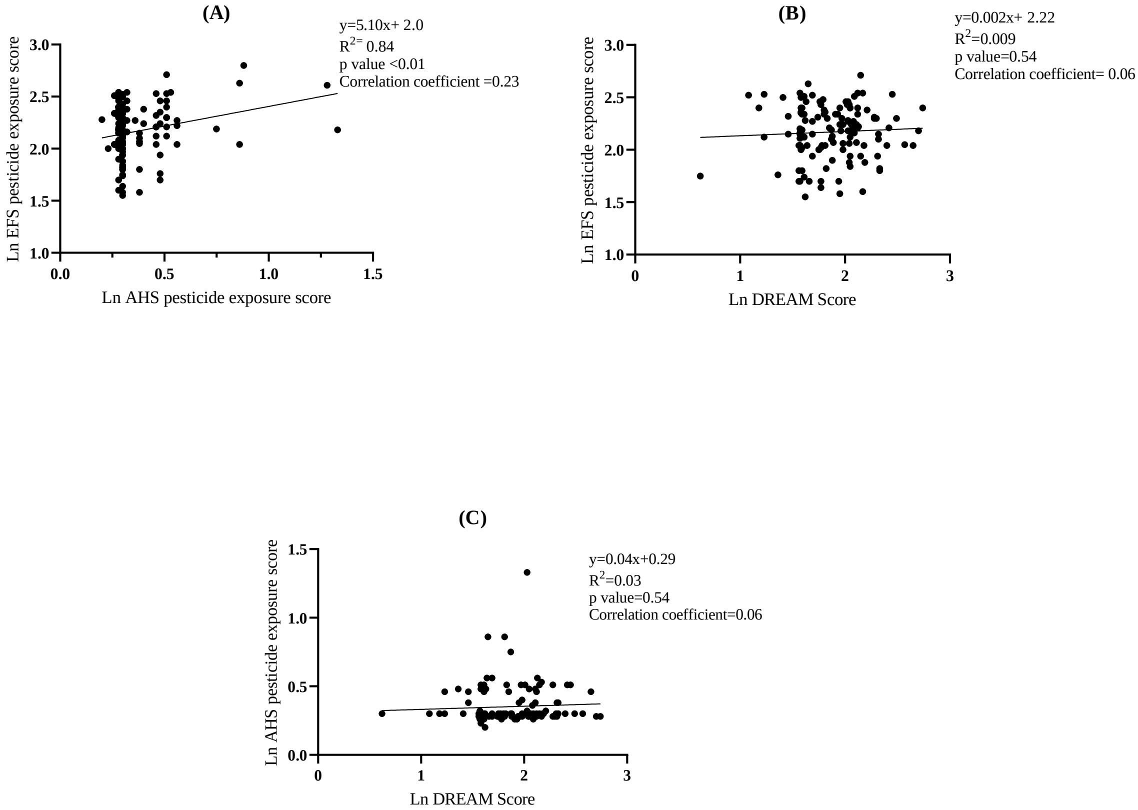


Figure 4.8: Correlations between Ln AHS, Ln EFS pesticide exposure intensity scores and Ln DREAM scores

(A) Scatter plot of Ln AHS and Ln EFS pesticide exposure intensity score, (B) Scatter plot of Ln DREAM Scores and Ln EFS pesticide exposure intensity score, and (C) Scatter plot of Ln DREAM Scores and Ln AHS pesticide exposure intensity score

4.2.3.4 Urine metabolites and demographics and working practices

The categorisation of level of urinary metabolites has been explained in Section 2.8 (Table 2.4).

Table 4.16 shows the associations between level of urinary metabolites and demographic factors among the farmers. There was no significant association between urine metabolite and demographic factors.

Table 4.16: Associations between level of urinary metabolites and demographic factors

Variable	Total (n=25)	Level of urinary metabolites		
		Minimal/Low [a] (n=12)	High/Very high [b] (n=13)	P value
Age, yrs				0.18 [c]
Mean ±SD	43.6 ±16.2	48.2± 16.7	39.3± 15.1	
Range	17-72	26-72	17-68	
BMI, n (%)				0.12 [d]
Under weight	3 (12.0)	0 (0.0)	3 (23.1)	
Normal weight	16 (64.0)	8 (66.7)	8 (61.3)	
Overweight/Obesity	6 (24.0)	4 (33.3)	2 (15.4)	
Marital status, n (%)				0.32 [d]
Single	5 (20.0)	1 (8.3)	4 (30.8)	
Married/Widower	20 (80.0)	11 (91.7)	9 (69.2)	
Educational level, n (%)				0.07 [d]
Never been to school	1 (4.0)	0 (0.0)	1 (7.7)	
Primary education	7 (28.0)	4 (33.3)	3 (23.1)	
Secondary education	13 (52.0)	4 (33.3)	9 (69.2)	
Tertiary education	4 (16.0)	4 (33.3)	0 (0.0)	
Income per month, n (%)				0.87 [e]
Lower income	15 (60.0)	7 (58.3)	8 (61.5)	
Middle income	10 (40.0)	5 (41.7)	5 (38.5)	
Smoking status, n (%)				0.14 [e]
Current/ex-smokers	15 (60.0)	9 (75.0)	6 (46.2)	
Non smokers	10 (40.0)	3 (25.0)	7 (53.8)	

[a] 0 or 1 differ scores of urinary metabolites above median, [b] 2 or 3 differs scores of urinary metabolites above median, [c] P value by Independent t-test, [d] P value by Fisher Exact test, [e] P value by Chi-Square test

Table 4.17 shows the associations between the level of urine metabolites and working practices during the first 24 hours of spraying. All of the farmers who had minimal/low level of urinary metabolites used backpacker sprayers compared to nearly half of farmers who had high/very high level of urinary metabolites ($p<0.01$). Farmers who had high/very high level of urinary metabolites were exposed more on their head or face ($p=0.03$) compared to those farmers who had minimal/low level of urinary metabolites.

Table 4.18 describes the associations between level of urinary metabolites and pesticide exposure intensity algorithm and DREAM scores. There was no significant association between level of urinary metabolites and pesticide exposure intensity algorithm and DREAM scores.

Table 4.17: Associations between level of urine metabolites and working practices on first 24 hours of spraying

Variable	Total (n=25)	Level of urinary metabolites		
		Minimal/Low [a] (n=12)	High/Very high [b] (n=13)	P value [c]
Duration of spraying				0.16
Less than one hour	20 (80.0)	8 (66.7)	12 (92.3)	
More than one hour	5 (20.0)	4 (33.3)	1 (7.7)	
Amount of pesticide				0.07
Less than 30 ml	12 (48.0)	8 (66.7)	4 (30.8)	
More than 30 ml	13 (52.0)	4 (37.3)	9 (69.2)	
Application methods, n (%)				<0.01
Backpack sprayer	18 (72.0)	12 (100)	6 (46.2)	
Power sprayer/ Blower	7 (28.0)	0 (0.0)	7 (53.8)	
Clothes worn during application, n (%)				
Hat	17 (68.0)	10 (83.3)	7 (53.8)	0.20
Goggles	0 (0.0)	0 (0.0)	0 (0.0)	Not examined
Dusk mask	11 (44.0)	7 (58.3)	4 (30.8)	0.17
Face shields	4 (16.0)	2 (16.7)	2 (15.4)	1.00
Gloves	5 (20.0)	2 (16.7)	3 (23.1)	1.00
Long sleeve shirt	19 (76.0)	8 (66.7)	11 (84.6)	0.38
Short sleeve shirt	5 (20.0)	3 (25.0)	2 (15.4)	0.65
Apron	1 (4.0)	0 (0.0)	1 (7.7)	1.00
Chemically resistant suit	1 (4.0)	1 (8.3)	0 (0.0)	0.48
Long trousers	23 (93.0)	11 (91.7)	12 (92.3)	1.00
Short trousers	2 (7.0)	1 (8.3)	1 (7.7)	1.00
Chemically resistant boots	20 (80.0)	10 (83.3)	10 (76.9)	1.00
Shoes	2 (7.0)	1 (8.3)	1 (7.7)	1.00
Body contact with pesticide during application, n (%)				
Head or face	12 (48.0)	3 (25.0)	9 (69.2)	0.03
Arms	20 (80.0)	11 (91.7)	9 (69.2)	0.32
Chest, back and abdomen	12 (48.0)	5 (41.7)	7 (53.8)	0.54
Legs	11 (44.0)	4 (33.3)	7 (53.8)	0.30
Feet	9 (36.0)	6 (50.0)	3 (23.1)	0.16
Wash equipment after pesticide use, n (%)				0.07
Yes	6 (24.0)	5 (41.7)	1 (7.7)	
No	19 (76.0)	7 (58.3)	12 (92.3)	
Repair spraying or mixing equipment, n (%)				0.65
Yes	5 (20.0)	3 (25.0)	2 (15.4)	
No	20 (80.0)	9 (75.0)	11 (84.6)	

[a] 0 or 1 differ scores of urinary metabolites above median, [b] 2 or 3 differs scores of urinary metabolites above median, [c] P value by Fisher Exact test

Table 4.18: Associations between level of urinary metabolites and EFS and AHS pesticide exposure intensity algorithm scores and DREAM scores

Variable	Level of urinary metabolites		
	Minimal/Low [a] (n=12)	High/Very high [b] (n=13)	P value [c]
EFS score (n=25)			0.21
Median (Q1-Q3)	244.9 (145.7-283.0)	133.3 (108.8-319.7)	
AHS score (n=25)			0.36
Median (Q1-Q3)	2.4 (2.3-3.3)	2.4 (2.2-2.9)	
DREAM scores (n=20)			0.78
Median (Q1-Q3)	75.0 (36.9-109.5)	62.1 (37.8-109.4)	

[a] 0 or 1 differ scores of urinary metabolites above median, [b] 2 or 3 differs scores of urinary metabolites above median, [c] P value by Mann-Whitney U test

4.2.4 Health status at baseline

Table 4.19 shows the baseline self-reported health status of the farmers. The majority of farmers (71.3%) reported that they were in good or very good health and only 12.0% of the farmers reported having poor health. 17.9% of the vegetable/fruit farmers were in poor health as compared to 7.2% of rice farmers but this difference was not statistically significant (p=0.14).

High blood pressure was the commonest illness reported by 14.7% of the farmers with diabetes reported by 7%. None of the farmers reported illnesses such as Parkinson disease, depression, anxiety and stress.

5.3% of the farmers reported an illness caused or made worse by work. Rice farmers reported that lung diseases, muscle and skeleton disorders and skin diseases were made worse by work more than vegetable/fruit farmers (p<0.05).

4.2.5 Screen positive somatic and neuropsychiatric symptoms among the farmers in the past 4 weeks

Table 4.20 shows the prevalence of somatic symptoms reported by farmers in the past 4 weeks. Very few of the farmers were bothered a lot by back pain (1.3%), pain in arms, legs or joints (1.3%), headache (2.0%), chest pain (0.7%), dizziness (1.3%),

Table 4.19: The health characteristics of farmers

Variable	Total (n=150)	Type of farming		
		Rice (n=83)	Vegetable/ Fruit (n=67)	P value
General health, n (%)				0.14 [a]
Very good	56 (37.3)	31 (37.3)	25 (37.3)	
Good	51 (34.0)	33 (39.8)	18 (26.9)	
Average	25 (16.7)	13 (15.7)	12 (17.9)	
Poor	18 (12.0)	6 (7.2)	12 (17.9)	
Previous illness, n (%)				
Heart disease including angina	4 (2.7)	2 (2.4)	2 (3.0)	1.00 [b]
High blood pressure	22 (14.7)	11 (13.3)	11 (16.5)	0.59 [a]
Asthma	3 (2.0)	3 (3.6)	0 (0)	0.25 [b]
Diabetes	11 (7.3)	6 (7.2)	5 (7.5)	1.00 [a]
Any illness caused or made worse by work, n (%)				0.30 [b]
Yes	8 (5.3)	6 (7.2)	2 (3.0)	
No	142 (94.7)	77 (92.8)	65 (97)	
Main illness made worse by work (n=8), n (%)				<0.05 [b]
Lung diseases	4 (50.0)	4 (66.6)	0 (0.0)	
Muscle and skeleton disorder	1 (12.5)	1 (16.7)	0 (0.0)	
Eye disorder	2 (25.0)	0 (0.0)	2 (100)	
Skin diseases	1 (12.5)	1 (16.7)	0 (0.0)	

[a] P value by Chi-Square test, [b] P value by Fisher Exact test

feeling their heart rate race (0.7%), shortness of breath (0.7%), nausea or gas (0.7%) and excessive sweating (1.3%). A relatively large number were bothered a little by back pain (25.3%), pain in arms, legs, or joints (26.0%), headache (14.0%) and dizziness (12.7%).

More than 90% of the farmers were not bothered by nine symptoms including stomach pain, pain during sexual intercourse, chest pain, fainting spells, feeling their heart rate race, shortness of breath, constipation, nausea and excessive sweating. There was no significant difference between each somatic symptom and type of farming (Data not shown).

Table 4.21 shows the severity of somatic symptoms reported by the farmers in the past 4 weeks. Thirteen farmers were categorized as having more than minimal symptoms.

Table 4.20: The prevalence of somatic symptoms reported by farmers in the past 4 weeks

Symptoms	Not bothered/ bothered at all [a]	Bothered at all	
		Bothered a little	Bothered a lot
a) Stomach pain	144 (96.0) /6 (4.0)	6 (4.0)	0 (0.0)
b) Back pain	110 (73.3)/ 40 (26.6)	38 (25.3)	2 (1.3)
c) Pain in your arms, legs, or joints	109 (72.7)/ 41 (27.3)	39 (26.0)	2 (1.3)
d)Pain or problems during sexual intercourse	149 (99.3)/ 1 (0.7)	1 (0.7)	0 (0.0)
e) Headache	126 (84.0)/ 24 (16.0)	21 (14.0)	3 (2.0)
f) Chest pain	141 (94.0)/ 9 (6.0)	8 (5.3)	1 (0.7)
g) Dizziness	129 (86.0)/ 21 (14.0)	19 (12.7)	2 (1.3)
h) Fainting spells	148 (98.7)/ 2(1.3)	2 (1.3)	0 (0)
i) Feeling your heart rate or race	142 (94.7)/ 8 (5.4)	7 (4.7)	1 (0.7)
j) Shortness of breath	141 (94.0)/ 9 (6.0)	8 (5.3)	1 (0.7)
k) Constipation, loose bowels or diarrhoea	148 (98.7)/ 2 (1.3)	2 (1.3)	0 (0.0)
l) Nausea, gas or indigestion	148 (98.7)/ 2(1.3)	1 (0.7)	1 (0.7)
m) Excessive sweating	144 (96.0)/ 6 (4.0)	4 (2.7)	2 (1.3)

[a] Bothered at all is combination of bothered a little and bothered a lot

Table 4.21: The severity of somatic symptoms in the past 4 weeks

Variable	Total (n=150)	Type of farming		
		Rice (n=83)	Vegetable/ Fruit (n=67)	P value
Somatic severity symptoms, n (%)				0.64 [a]
Minimal (0-3)	137 (91.3)	75 (90.4)	62 (92.5)	
Low (4-8)	11 (7.3)	6 (7.2)	5 (7.5)	
Medium (9-12)	1 (0.7)	1 (1.2)	0 (0.0)	
High (13-26)	1 (0.7)	1 (1.2)	0 (0.0)	
Somatic symptoms, n (%)				0.57 [b]
Not bothered	79 (52.7)	42 (50.6)	37 (55.2)	
Bothered at all [c]	71 (47.3)	41 (49.4)	30 (44.8)	

[a] P value by Fisher Exact test, [b] P value by Chi-Square test, [c] Bothered at all is combination of bothered a little and bothered a lot

There was no difference between severity score between those who were rice or vegetable/fruit farmers (p=0.64). 47.3% of farmers reported being bothered at all by any of the symptoms and there was no statistical difference between type of farming (p=0.57).

Table 4.22 shows the prevalence of Parkinsonism and neuropathy symptoms reported by the farmers in the past 4 weeks. Only one farmer was bothered a lot by nine out of 18 symptoms which included hand shaking, feeling unsteady, slowing down physically, difficulty in turning over in bed at night and standing up from a chair, losing balance, loss of sensation in hands and feet's, cramps or spasms in

Table 4.22: The prevalence of Parkinsonism and neuropathy symptoms reported by farmers in the past 4 weeks

Symptoms	Not bothered/ Bothered at all [a]	Bothered at all	
		Bothered a little	Bothered a lot
a) Doing up buttons on your clothes	149 (99.3)/ 1 (0.7)	1 (0.7)	0 (0.0)
b) Your hands shaking	141 (94.0)/ 9 (6.0)	8(5.3)	1(0.7)
c) Clumsiness	148 (98.7)/ 2(1.3)	2(1.3)	0 (0.0)
d)Slurring your words	150 (100)/ 0 (0.0)	0 (0.0)	0 (0.0)
e) Feeling unsteady when walking	141 (94.0)/ 9 (6.0)	8 (5.3)	1 (0.7)
f) Problems when using the telephone or cooking a meal	147 (98.0)/ 3 (2.0)	3 (2.0)	0 (0.0)
g) Moving more slowly or stiffly	148 (98.7)/ 2 (1.3)	2 (1.3)	0 (0.0)
h) Walking with a stooped posture	148 (98.7)/ 2 (1.3)	2 (1.3)	0 (0.0)
i)Not swinging your arms when you walk as much as you used to	148 (98.7)/ 2 (1.3)	2 (1.3)	0 (0.0)
j) Slowing down physically	146 (97.3)/ 4 (2.7)	3 (2.0)	1 (0.7)
k) Difficulty in turning over in bed at night	146 (97.3)/ 4 (2.7)	3 (2.0)	1 (0.7)
l) Difficulty in standing up from a chair	147 (98.0)/ 3 (2.0)	2 (1.3)	1 (0.7)
m) Losing your balance	144 (96.0)/ 6 (4.0)	5 (3.3)	1 (0.7)
n) Loss of sensation in your hands and feet	143 (95.3)/ 7 (4.7)	6 (4.0)	1 (0.7)
o) Feeling drunk when you haven't drunk too much	150 (100)/ 0 (0.0)	0 (0.0)	0 (0.0)
p) Cold hands or feet	145 (96.7)/ 5 (3.3)	5 (3.3)	0 (0.0)
q) Cramps or spasms in your muscles	139 (92.7)/ 11(7.4)	10 (6.7)	1 (0.7)
r) Having a weak feeling in yours arms and legs	139 (92.7)/ 11 (7.4)	10 (6.7)	1 (0.7)

[a] Bothered at all is combination of bothered a little and bothered a lot

muscles and weak feeling in arms and legs. More than 90% of the farmers were not bothered by any of the symptoms.

More rice farmers were bothered at all by feeling unsteady when walking (p=0.04) and loss of sensation in their hands and feet (p=0.02) compared to vegetable/fruit farmers (Data not shown). Table 4.23 shows the characteristic of Parkinsonism and neuropathy symptoms reported by the farmers in the past 4 weeks. There was one rice farmer who was identified as being screen positive for neuropathy. However, no screen-positive cases of Parkinsonism were identified and 18.0% of farmers reported being bothered at all by any of the symptoms and there was no statistical difference between type of farming (p=0.38).

Table 4.23: The characteristic of Parkinsonism and neuropathy symptoms in the past 4 weeks

Variable	Total (n=150)	Type of farming		
		Rice (n=83)	Vegetable/ Fruit (n=67)	P value
Screen positive Parkinsonism, n (%) [a]				Not measured
Yes	0 (0.0)	0 (0.0)	0 (0.0)	
No	150 (100)	83 (100)	67 (100)	
Screen positive neuropathy, n (%) [b]				1.00 [d]
Yes	1 (0.7)	1 (1.2)	0 (0.0)	
No	149 (99.3)	82 (98.8)	67 (100)	
Parkinsonism and neuropathy symptoms, n (%)				0.38 [e]
Not bothered	123 (82.0)	66 (79.5)	57 (85.1)	
Bothered at all [c]	27 (18.0)	17 (20.5)	10 (14.9)	

[a] The farmers were identified to be screen positive for Parkinsonism if they answered "bothered a lot" to one or more of (g), (h) and (i) questions in Table 6.4, [b] The farmers were identified to be screen positive for neuropathy if they answered "bothered a lot" to one or more of (a), (d),(k), (m), (n), (p) and (r) questions in Table 6.4, [c] Bothered at all is combination of bothered a little and bothered a lot, [d] P value by Fisher Exact test, [e] P value by Chi-Square test

Table 4.24 shows the prevalence of depression symptoms reported by the farmers in the past 4 weeks. One of the farmers was bothered a lot by three out of 12 depression symptoms which included troubling falling asleep, feeling tired and trouble concentrating. More than 90% of the farmers were not bothered by any of the depression symptoms. There was no significant difference between each symptom and type of farming (Data not shown).

Table 4.25 shows the characteristic of depression symptoms reported by the farmers in the past 4 weeks. There were no screen positive cases of depression identified and only 9.3% of farmers were categorised as being bothered at all by any depression symptoms and there was no statistically difference with the type of farming (p=0.58).

Table 4.24: The prevalence of depression symptoms reported by farmers in the past 4 weeks

Symptoms	Not bothered/ Bothered at all [a]	Bothered at all	
		Bothered a little	Bothered a lot
a) Little interest or pleasure in doing things	146 (97.3)/ 4 (2.7)	4 (2.7)	0 (0.0)
b) Feeling down, depressed or hopeless	148 (98.7)/ 2 (1.3)	2 (1.3)	0 (0.0)
c)Troubling falling or staying asleep	147 (98.0)/ 3 (2.0)	2 (1.3)	1 (0.7)
d)Sleeping too much	147 (98.0)/ 3 (2.0)	3 (2.0)	0 (0.0)
e) Feeling tired or having little energy	142 (94.7)/8 (5.4)	7 (4.7)	1 (0.7)
f) Poor appetite or overeating	145 (96.7)/ 5 (3.3)	5 (3.3)	0 (0.0)
g) Feeling bad about yourself or that you are a failure or have let yourself or your family down	150 (100)/ 0 (0.0)	0 (0.0)	0 (0.0)
h)Trouble concentrating on things, such as reading the newspaper or watching television	148 (98.7)/ 2 (1.4)	1 (0.7)	1 (0.7)
i)Moving or speaking so slowly that other people could have noticed	149 (99.3)/ 1 (0.7)	1 (0.7)	0 (0.0)
j) Being so fidgety or restless that you have been moving around a lot more than usual	149 (99.3)/ 1 (0.7)	1 (0.7)	0 (0.0)
k) Thoughts that life is not worth living	149 (99.3)/ 1 (0.7)	1 (0.7)	0 (0.0)

[a] Bothered at all is combination of bothered a little and bothered a lot

Table 4.25: The characteristic of depression symptoms in the past 4 weeks

Variable	Total (n=150)	Type of farming		
		Rice (n=83)	Vegetable/ Fruit (n=67)	P value [c]
Screen positive Depression, n (%) [a]				Not measured
Yes	0 (0.0)	0 (0.0)	0 (0.0)	
No	150 (100)	83 (100)	67 (100)	
Depression symptoms, n (%)				0.58
Not bothered	136 (90.7)	74 (89.5)	62 (92.5)	
Bothered at all [b]	14 (9.3)	9 (10.5)	5 (7.5)	

[a] The farmers were determined to be screen positive for depression if they answer bothered a lot to (a) or (b) and 4 or more of (a) – (k) questions Table 6.6 were at bothered a lot in the past 4 weeks, [b] Bothered at all is combination of bothered a little and bothered a lot,[c] P value by Chi-Square test

Table 4.26 shows the prevalence of dementia symptoms reported by the farmers in the past 4 weeks. The majority of farmers reported no symptoms and five farmers reported being bothered a lot by any of the symptoms. More rice farmers were bothered at all with trouble with short-term memory (p=0.02), needing reminders to do things (p=0.02) and forgetting appointments, family occasions or holidays (p=0.01) compared to vegetable/fruit farmers (Data not shown).

Table 4.26: The prevalence of dementia symptoms reported by farmers in the past 4 weeks

Symptoms	Not bothered/ Bothered at all [a]	Bothered at all	
		Bothered a little	Bothered a lot
a) Do you often repeat yourself or ask the same question over and over?	144 (96.0)/ 6 (4.0)	4 (2.7)	2 (1.3)
b) Are you more forgetful, that is, having trouble with short-term memory?	133 (88.7)/ 17 (11.3)	14 (9.3)	3 (2.0)
c) Do you need reminders to do things like chores, shopping or taking medicine?	140 (93.3)/ 10 (6.6)	8 (5.3)	2 (1.3)
d)Do you forget appointments, family occasions or holidays?	138 (92.0)/ 12 (8.0)	11 (7.3)	1 (0.7)
e) Are you sad, down in the dumps or cry more often than in the past?	149 (99.3)/ 1 (0.7)	1 (0.7)	0 (0.0)
f) Have you started having double doing calculations, managing finances or balancing the chequebook?	147 (98.0)/ 3 (2.0)	2 (1.3)	1 (0.7)
g) Have you lost interest in your usual activities such as hobbies, reading, church or other social activities?	148 (98.7)/ 2 (1.4)	1 (0.7)	1 (0.7)
h) Have you started needing help eating, dressing, bathing or using the bathroom?	150 (100)/ 0 (0.0)	0 (0.0)	0 (0.0)
i)Have you become irritable, agitated or suspicious, or started seeing, hearing or believing things that are not real?	150 (100)/ 0 (0.0)	0 (0.0)	0 (0.0)
j) Are you concerned about your driving, for example, getting lost or driving unsafely?	149 (99.3)/ 1 (0.7)	1 (0.7)	0 (0.0)
k) Do you have trouble finding the words you want to say, or naming people or things?	147 (98.0)/ 3 (2.0)	3 (2.0)	0 (0.0)
l) Do you think you're having trouble with your nerves?	145 (96.7)/ 5 (3.3)	5 (3.3)	0 (0.0)

[a] Bothered at all is combination of bothered a little and bothered a lot

Table 4.27 shows the characteristic of dementia symptoms reported by the farmers in the past 4 weeks. One screen positive case of dementia was identified and there was no statistically difference with the type of farming (p=1.00). Only 16.0% of farmers were categorised as being bothered at all by any dementia symptoms and with 20.5% of rice farmers being so bothered as compared to 10.4% of vegetable/fruit farmers (p=0.10)

Table 4.27: The characteristic of dementia symptoms

Variable	Total (n=150)	Type of farming		
		Rice (n=83)	Vegetable/ Fruit (n=67)	P value
Screen positive dementia, n (%) [a]				1.00 [c]
Yes	1 (0.7)	1 (1.2)	0 (0.0)	
No	149 (99.3)	82 (98.8)	67 (100)	
Dementia symptoms, n (%)				0.10 [d]
Not bothered	126 (84.0)	66 (79.5)	60 (89.6)	
Bothered at all [b]	24 (16.0)	17 (20.5)	7 (10.4)	

[a] The farmers were screen positive for dementia if they answer bothered a lot to (a), (i) or (j) questions in Table 6.8 and the severity cumulative score was greater than 4 or more if each positive answer was scored as 1, [b] Bothered at all is combination of bothered a little and bothered a lot, [c] P value by Fisher Exact test, [d] P value by Chi-Square test

4.2.6 Associations between ill health and demographic factors, working practices and pesticide exposure

4.2.6.1 Associations between ill health and demographic factors

Table 4.28 shows the associations between average or poor general health and high blood pressure and demographic factors among the farmers. The farmers with average or poor health were older ($p<0.01$), married ($p=0.01$), overweight or obese ($p=0.02$) and had never been to school ($p=0.02$). Meanwhile, older farmers reported high blood pressure more than younger farmers ($p<0.01$).

Table 4.29 shows the associations between somatic and neuropsychiatry symptoms and demographic factors among the farmers. The farmers who reported being bothered at all by somatic symptoms and dementia were older than those not bothered ($p<0.01$). The farmers who reported being bothered at all by Parkinsonism symptoms were older ($p<0.01$), more likely to be married ($p=0.01$) and from lower income families ($p=0.02$) than those not bothered. The farmers who reported being bothered at all by depression symptoms were older ($p=0.02$) and from lower income families ($p=0.01$) than those not bothered.

4.2.6.2 Associations between ill health and occupational histories and working practices

Table 4.30 shows the associations between average or poor general health and high blood pressure and occupational histories and working practices of the farmers during previous spraying sessions. The work duration of farmers who reported average or poor health was longer than those farmers who reported very good/good health ($p<0.01$) and they also started working early than those farmers who reported very good/ good health ($p=0.04$). However, the farm size was smaller in farmers who reported average/poor health than those reported very good/good health ($p<0.01$). Interestingly, the farmers who had average or poor health normally sprayed less than one day per week than those who reported very good/good health status ($p=0.01$).

Those who reported having a high blood pressure had worked for longer as a farmer compared to those who had worked less ($p<0.01$). The farmers who reported having high blood pressure were more likely to have had an incident while using pesticide compared to those farmers who reported normal blood pressure ($p=0.04$).

Table 4.31 shows the associations between somatic and neuropsychiatry symptoms and occupational history and working practices of the farmers during previous spraying session. The farmers who reported being bothered at all by somatic symptoms had worked as farmers longer than those who were not bothered ($p<0.01$). The farmers who reported being bothered at all by Parkinsonism symptoms had work as farmers longer ($p<0.01$) were more likely to re-enter into sprayed field ($p=0.04$), had had incidents while using pesticides $p=0.01$) and had not used PPE ($p=0.02$) compared to those not bothered.

The farmers who reported being bothered at all by depression symptoms were more likely to have had an incident while using pesticides than those not bothered ($p=0.02$). The farmers who reported being bothered at all by dementia symptoms had started working at a younger age ($p=0.01$) and had worked as farmers longer ($p=0.01$) than those not bothered.

4.2.6.3 Associations between ill health and post work hygienic behaviour of farmers

Table 4.32 shows the associations between average or poor health and high blood pressure and washing and showering behaviours of the farmers during previous spraying sessions and Table 4.33 shows the associations between somatic and neuropsychiatry symptoms and washing and showering behaviours of the farmers during previous spraying sessions. There were no statistically significant differences in washing and showering behaviours of the farmers and ill-health.

Table 4.34 shows the associations between average or poor health and high blood pressure and repairing and cleaning equipment after spraying during previous spraying sessions and Table 4.35 shows the associations between somatic and

Table 4.28: Associations between average/poor general health and high blood pressure and demographic factors

Variable	Average/poor general health condition			High blood pressure		
	Very good/ good (n=107)	Average/Poor (n=43)	P value	Yes (n=22)	No (n=128)	P value
Age, yrs			<0.01 [a]			<0.01 [a]
Mean±SD	43.0±15.3	59.0 ±10.4		61.3±12.9	45.2 ±15.1	
Min-Max	17-77	36-81		23-81	17-77	
BMI, n (%)			0.02 [b]			0.34 [b]
Under weight	10 (9.3)	0 (0.0)		2 (9.1)	8 (6.2)	
Normal weight	71 (66.4)	25 (58.1)		11 (50.0)	85 (66.4)	
Overweight	23 (21.5)	14 (32.6)		8 (36.4)	29 (22.7)	
Obesity	3 (2.8)	4 (9.3)		1 (4.5)	6 (4.7)	
Marital status, n (%)			<0.01 [b]			0.29 [b]
Single	26 (24.4)	0 (0.0)		1 (4.5)	25 (19.5)	
Married	79 (73.8)	42 (97.7)		21 (95.5)	100 (78.1)	
Widowed/Divorced	2 (1.8)	1 (2.3)		0 (0.0)	3 (2.4)	
Educational level, n (%)			0.02 [b]			0.53 [b]
Never been to school	4 (3.7)	6 (14.0)		3 (13.6)	7 (5.5)	
Primary education	32 (29.9)	9 (20.9)		6 (27.4)	35 (27.3)	
Secondary education	63 (58.9)	24 (55.8)		12 (54.5)	75 (58.6)	
Tertiary education	8 (7.5)	4 (9.3)		1 (4.5)	11 (8.6)	
Income per month, n (%)			1.00 [c]			0.45 [c]
Low income	62 (57.9)	25 (58.1)		15 (68.2)	72 (56.2)	
Middle income	45 (42.1)	18 (41.9)		7 (31.8)	56 (43.8)	
Smoking status, n (%)			0.05 [c]			0.48 [c]
Current/ex-smokers	70 (65.4)	35 (81.4)		14 (63.6)	91 (71.1)	
Non-smokers	37 (34.6)	8 (18.6)		8 (36.4)	37 (28.9)	

[a] P value by Independent T-test, [b] P value by Fisher Exact test, [c] P value by Chi-Square test

Table 4.29: Associations between somatic and neuropsychiatry symptoms and demographic factors

Variable	Somatic symptoms		Parkinsonism/neurology symptoms		Depression symptoms		Dementia symptoms	
	Not Bothered (n=79)/ Bothered at all (n=71)	P value	Not Bothered (n=123)/ Bothered at all (n=27)	P value	Not Bothered (n=136)/ Bothered at all (n=14)	P value	Not Bothered (n=126)/ Bothered at all (n=24)	P value
Age, yrs		<0.01 [a]		<0.01 [a]		0.02 [a]		<0.01 [a]
Mean±SD	44.6±15.3/50.9±15.8		44.8±14.9/60.2±13.9		46.6±15.8/57.2±13.6		45.1±15.3/56.3 ±15.8	
Min-Max	17-75/18-81		17-75/29-81		17-81/36-77		17-81/24-77	
BMI, n (%)		0.30 [b]		0.93 [b]		0.75 [b]		0.32 [b]
Under weight	4 (5.1)/ 6(8.5)		9 (7.3)/ 1 (3.7)		9 (6.6)/ 1 (7.1)		10 (7.9)/ 0 (0.0)	
Normal weight	50 (63.3)/ 46 (64.8)		77 (62.6)/ 19 (70.4)		88 (64.7)/ 8 (57.2)		77 (61.1)/ 19 (79.2)	
Overweight	19 (24.0)/ 18 (25.4)		31 (25.2)/ 6 (22.2)		33 (24.3)/ 4 (28.6)		32 (25.4)/ 5 (20.8)	
Obesity	6 (7.6)/ 1 (1.3)		6 (4.9)/ 1 (3.7)		6 (4.4)/ 1 (7.1)		7 (5.6)/ 0 (0.0)	
Marital status, n (%)		0.14 [b]		0.01 [b]		0.22 [b]		0.21 [b]
Single	17 (21.5)/ 9 (12.7)		26 (21.1)/ 0 (0.0)		26 (19.1)/ 0 (0.0)		25 (19.8)/ 1 (4.2)	
Married	60 (75.9)/ 61 (85.9)		94 (76.4)/ 27 (100.0)		107 (78.7)/ 14 (100.0)		98 (77.8)/ 23 (95.8)	
Widowed/Divorced	2 (2.6)/ 1 (1.4)		3(2.4)/ 0 (0.0)		3 (2.2)/ 0 (0.0)		3 (2.4)/ 0 (0.0)	
Educational level, n (%)		0.23 [b]		0.06 [b]		0.31 [b]		0.30 [b]
Never been to school	3 (3.8)/ 7 (9.9)		6 (4.9)/ 4 (14.8)		9 (6.6)/ 1 (7.1)		8 (6.3)/ 2 (8.3)	
Primary education	22 (27.8)/ 19 (26.8)		36 (29.2)/ 5 (18.5)		36 (26.5)/ 5 (35.7)		36 (28.6)/ 5 (20.8)	
Secondary education	45 (57.0)/ 42 (59.2)		69 (56.1)/ 18 (66.7)		79 (58.1)/ 8 (57.2)		70 (55.6)/ 17 (70.8)	
Tertiary education	9 (11.4)/ 3 (4.1)		12 (9.8)/ 0 (0.0)		12 (8.8)/ 0 (0.0)		12 (9.5)/ 0 (0.0)	
Income per month, n (%)		0.25 [c]		0.02 [c]		0.01 [b]		0.85 [c]
Low income	42 (53.1)/ 45 (63.4)		65 (52.8)/ 22 (81.5)		74 (54.4)/ 13 (92.9)		72 (57.1)/ 15 (62.5)	
Middle income	37 (46.9)/ 26 (36.6)		58 (47.2)/ 5 (18.5)		62 (45.6)/ 1 (7.1)		54 (42.9)/ 9 (37.5)	
Smoking status, n (%)		0.80 [c]		0.61 [c]		0.27 [b]		0.29 [c]
Current/ex-smokers	56 (70.9)/ 49 (69.0)		85 (69.1)/ 20 (74.1)		134 (98.5)/ 13 (92.9)		86 (68.3)/ 19 (79.2)	
Non-smokers	23 (29.1)/ 22 (31.0)		38 (30.9)/ 7 (25.9)		2 (1.5)/ 1 (7.1)		40 (31.7)/ 5 (20.8)	

[a] P value by Independent T-test, [b] P value by Fisher Exact test, [c] P value by Chi-Square test

Table 4.30: Associations between average/poor general health and high blood pressure and occupational histories and working practices during previous spraying sessions

Variable	Average/poor general health condition			High blood pressure		
	Very good/good (n=107)	Average/ Poor (n=43)	P value	Yes (n=22)	No (n=128)	P value
Age start working, yrs			0.04 [c]			0.79 [c]
Median (IQR)	18.0 (4.0)	17.0 (7.0)		16.0 (12.0)	18.0 (5.0)	
Duration work as farmers, yrs			<0.01 [c]			<0.01 [c]
Median (IQR)	12.0 (25.0)	36.0 (22.0)		33.5 (25.5)	14.5 (28.8)	
Farm size, acre			<0.01 [c]			0.17 [c]
Median (IQR)	5.0 (8.0)	2.0 (5.0)		2.8 (3.3)	4.0 (8.0)	
Spraying per day, hour			0.06 [c]			0.85 [c]
Median (IQR)	1.0 (0.0)	1.0 (1.0)		2.0 (1.0)	2.0 (1.0)	
Days sprayed per week, n (%)			0.01 [d]			0.89 [d]
1 day or less	20 (18.7)	18 (41.9)		6 (27.3)	32 (25.0)	
2-3 days	67 (62.6)	16 (37.2)		12 (54.5)	71 (55.5)	
4-5 days	12 (11.2)	7 (16.3)		2 (9.1)	17 (13.3)	
6-7 days	8 (7.5)	2 (4.7)		2 (9.1)	8 (6.3)	
Mixing pesticide, n (%)			0.63 [d]			0.55 [d]
<50% of time	3 (2.8)	2 (4.7)		1 (4.5)	4 (3.1)	
>50% of time	104 (97.2)	41 (95.3)		21 (95.5)	124 (96.9)	
Application methods, n (%)			0.12 [d]			0.88 [d]
Backpack sprayer	71 (66.4)	35 (81.4)		17 (77.3)	89 (69.5)	
Power sprayer	15 (14.0)	5 (11.6)		2 (9.1)	18 (14.1)	
Blower	21 (19.6)	3 (7.0)		3 (13.6)	21 (16.4)	
Bystander exposure, n (%)			1.00 [e]			1.00 [d]
Yes	23 (21.5)	9 (20.9)		4 (18.2)	28 (21.9)	
No	84 (78.5)	34 (79.1)		18 (81.8)	100 (78.1)	
Re-entry into the sprayed field, n (%)			1.00 [e]			0.71 [e]
Yes	27 (25.2)	11 (25.6)		5 (22.7)	33 (25.8)	
No	80 (74.8)	32 (74.4)		17 (77.3)	95 (74.2)	

Incident while using pesticide, n (%)			1.00 [e]			0.04 [e]
Yes	26 (24.3)	10 (23.3)		9 (40.9)	27 (21.1)	
No	81 (75.7)	33 (76.7)		13 (59.1)	101 (78.9)	
Nature of incident, n (%); n (36)			0.22 [d]			1.00 [d]
Leakage	9 (34.6)	1 (10.0)		2 (22.2)	8 (29.6)	
Spillage	17 (65.4)	9 (90.0)		7 (77.8)	19 (70.4)	
PPE used, n (%)			0.58 [e]			0.35 [e]
Yes	80 (74.8)	34 (79.1)		15 (68.2)	99 (77.3)	
No	27 (25.2)	9 (20.9)		7 (31.8)	29 (22.7)	

[a] Good knowledge scores is when the score above median and poor knowledge scores is when the score below median, [b] Good practice scores is when the score above median and poor practice scores is when the score below median, [c] P value by Mann- Whitney U test, [d] P value by Fisher Exact test, [e] P value by Chi-Square test

neuropsychiatry symptoms and repairing and cleaning equipment after spraying during previous spraying sessions. The farmers who were bothered at all by depression symptoms used cleaning agents more than those farmers who were not bothered (p=0.01).

4.2.6.4 Associations between ill health and pesticide use

Table 4.36 shows the associations between average/poor general health and high blood pressure and pesticide use of the farmers during first day of current spraying week. The farmers who reported very good/good health used fungicides more (p=0.02) used more than one pesticide (p=0.01) compared to that reporting average or poor health. The farmers who reported having high blood pressure used herbicides more than farmer who reported normal blood pressure (p=0.01).

Table 4.37 shows the associations between somatic and neuropsychiatry symptoms and pesticide use of the farmers during first day of current spraying week. The farmers who reported being bothered at all by Parkinsonism symptoms were more likely to use herbicides than those not bothered (p=0.04). Otherwise, there were no associations between somatic and neuropsychiatry symptoms and number of pesticides and type of pesticides use.

4.2.6.5 Association between ill health and pesticide exposure

Table 4.38 shows the associations between average/poor general health and high blood pressure and pesticide exposure. The farmers who reported very good/good health had higher pesticide exposure score based on EFS compared to that reporting average or poor health (p=0.01). Inversely, the farmers who reported having high blood had lower pesticide exposure score based on EFS than farmer who reported normal blood pressure (p<0.01).

Table 4.39 shows the associations between somatic and neuropsychiatry symptoms and current pesticide exposure. There were no associations between somatic and neuropsychiatry symptoms and current pesticide exposure.

4.2.7 Logistic regression analysis of potential pesticide risk factors for ill health

4.2.7.1 Pesticide exposure and average/poor general health among the farmers

Table 4.40 shows the final model for pesticide predictors for average/poor general health among the farmers. Binary logistic regression adjusted analyses included the following potential confounders such as age, BMI, educational level, age start working, duration work as farmers and farm size showed that farmers who sprayed less than 1 day per week had 5-fold increased risk (OR=5.22; 95%CI: 1.69, 17.22) of having average/poor health.

4.2.7.2 Pesticide exposure and high blood pressure among the farmers

Table 4.41 shows the final model for pesticide predictors for high blood pressure among the farmers. Binary logistic regression adjusted analyses included the following potential confounders such as age and duration work as farmers found that farmers who had an incident while using pesticide had nearly 4-fold (OR=4.06; 95%CI: 1.21, 11.66) increased risk of having high blood pressure.

4.2.7.3 Pesticide exposure and Parkinsonism and neurology symptoms among the farmers

Table 4.42 shows the final model for pesticide predictors for being bothered at all by Parkinsonism/neurology symptoms among the farmers. Binary logistic regression adjusted analyses included the following potential confounders such as age, income, duration work as farmers found that farmers who had incident while using pesticide had 4-folds increase (OR=4.48; 95%CI:1.46, 10.94) of having bothered at all of Parkinsonism/neurology symptoms.

4.2.7.4 Pesticide exposure and depression symptoms among the farmers

Table 4.43 shows the final model for pesticide predictors for being bothered at all by depression symptoms among the farmers. Binary logistic regression adjusted analyses included the following potential confounders such as age and income, found a trend

Table 4.31: Associations between somatic and neuropsychiatry symptoms and occupational history and work practices

Variable	Somatic symptoms		Parkinsonism/neurology symptoms		Depression symptoms		Dementia	
	Not Bothered (n=79)/ Bothered at all (n=71)	P value	Not Bothered (n=123)/ Bothered at all (n=27)	P value	Not Bothered (n=136)/ Bothered at all (n=14)	P value	Not Bothered (n=126)/ Bothered at all (n=24)	P value
Age start working, yrs		0.99 [c]		0.13 [c]		0.40 [c]		0.01 [c]
Median (Q1-Q3)	18.0 (4.0)/ 18.0 (5.0)		18.0 (5.0)/ 18.0 (6.0)		18.0 (5.0) /18.0 (3.0)		18.0 (4.0)/ 14.5 (6.0)	
Duration work as farmers, yrs		<0.01 [c]		<0.01 [c]		0.17 [c]		0.03 [c]
Median (Q1-Q3)	12.0 (26.0)/ 30.0 (32.0)		14.0 (28.0)/ 36.0 (25.0)		16.5 (30.8)/ 27.5 (20.3)		16.5 (28.3)/ 34.5(36.8)	
Farm size, acre		0.30 [c]		0.60 [c]		0.10 [c]		0.35 [c]
Median (Q1-Q3)	3.0 (7.0)/ 5.0 (8.0)		4.0 (8.0)/ 4.0 (6.0)		3.8 (7.8) /8.0 (18.0)		3.6 (8.0)/ 4.0 (6.1)	
Spraying per day, hour		0.77 [c]		0.06 [c]		0.06 [c]		0.73 [c]
Median (Q1-Q3)	1.0 (1.0)/ 1.0 (0)		1.0 (1.0)/ 1.0 (1.0)		1.0 (1.0) /1.0 (2.0)		10 (1.0)/ 1.0 (0)	
Days sprayed per week, n (%)		0.57 [d]		0.40 [e]		0.13 [e]		0.07 [e]
1 day or less	22 (27.8)/ 16 (22.5)		34 (27.6)/ 4 (14.8)		34 (25.1)/ 4 (28.6)		36 (28.6)/ 2 (8.3)	
2-3 days	45 (57.0)/ 38 (53.5)		67 (54.5)/ 16 (59.3)		77 (56.6)/ 6 (42.9)		66 (52.4)/ 17 (70.8)	
4-5 days	8 (10.1)/ 11 (15.5)		15 (12.2)/ 4 (14.8)		18 (13.2)/ 1 (7.1)		17 (13.4)/ 2 (8.3)	
6-7 days	4 (5.1)/ 6 (8.5)		7 (5.7)/ 3 (11.1)		7 (5.1)/ 3 (21.4)		7 (5.6)/ 3 (12.6)	
Mixing pesticide, n (%)		0.19 [e]		1.00 [e]		1.00 [e]		0.59 [e]
<50% of time	1 (1.3)/ 4 (5.6)		4 (3.3)/ 1 (3.7)		5 (3.7)/ 0 (0)		4 (3.2)/ 1 (4.2)	
>50% of time	78 (98.7)/ 67 (94.4)		119 (96.7)/ 26 (96.3)		131 (96.3)/ 14 (100.0)		122 (96.8)/ 23 (95.8)	
Application methods, n (%)		0.95 [d]		0.12 [e]		0.61 [e]		1.00 [e]
Backpack sprayer	56 (70.9)/ 50 (70.4)		83 (67.5)/ 23 (85.2)		94 (69.1)/ 12 (85.8)		89 (70.6)/ 17 (70.8)	
Power sprayer	11 (13.9)/ 9 (12.7)		17 (13.8)/ 3 (11.1)		19 (14.0)/ 1 (7.1)		17 (13.5)/ 3 (12.5)	
Blower	12 (15.2)/ 12 (16.9)		23 (18.7)/ 1 (3.7)		23 (16.9)/ 1 (7.1)		20 (15.9)/ 4 (16.7)	

Bystander farmers, n (%)		0.65 [d]		0.15 [e]		0.17 [d]		0.25 [e]
Yes	18 (22.8)/ 14 (19.7)		29 (23.6)/ 3 (11.1)		27 (19.9)/ 5 (35.7)		29 (23.0)/ 3 (12.5)	
No	61 (77.2)/ 57 (80.3)		94 (76.4)/ 24 (88.9)		109 (80.1)/ 9 (64.3)		97 (77.0)/ 21 (87.5)	
Re-entry into sprayed field, n (%)		0.26 [d]		0.04 [d]		0.35 [d]		0.14 [d]
Yes	17 (21.5)/ 21 (29.6)		27 (22.0)/ 11 (40.7)		33 (24.3)/ 5 (35.7)		29 (23.0)/ 9 (37.5)	
No	62 (78.5)/ 50 (70.4)		96 (78.0)/ 16 (59.3)		103 (75.7)/ 9 (64.3)		97 (77.0)/ 15 (62.5)	
Incident while using pesticide, n (%)		0.26 [d]		0.01 [d]		0.02 [d]		1.00 [d]
Yes	16 (20.3)/ 20 (28.2)		24 (19.5)/ 12 (44.4)		29 (21.3)/ 7 (50.0)		30 (23.8)/ 6 (25.0)	
No	63 (79.7)/ 51 (71.8)		99 (80.5)/ 15 (55.6)		107 (78.7)/ 7 (50.0)		96 (76.2)/ 18 (75.0)	
Nature of incident, n (%); n (36)		0.68 [d]		0.44 [e]		1.00 [e]		0.16 [d]
Leakage	5 (31.2)/5 (25.0)		8 (33.3)/2 (16.7)		8 (27.6)/2 (28.6)		10 (33.3)/0 (0.0)	
Spillage	11 (68.8)/15 (75.0)		16 (66.7)/10 (83.3)		21 (72.4)/5 (71.4)		20 (66.7)/6 (100)	
PPE used, n (%)		0.45 [d]		0.02 [d]		0.08 [d]		0.09 [d]
Yes	62 (78.4)/ 52 (73.2)		98 (79.7)/ 16 (59.3)		106 (77.9)/ 8(57.1)		99 (78.6)/ 15 (62.5)	
No	17 (21.6)/ 19 (26.8)		25 (20.3)/ 11 (40.7)		30 (22.1) /6 (42.9)		27 (21.4)/ 9 (37.5)	

[a] Good knowledge scores is when the score above median and poor knowledge scores is when the score below median, [b] Good practice scores is when the score above median and poor practice scores is when the score below median, [c] P value by Mann- Whitney U test, [d] P value by Chi-Square test, [e] P value by Fisher Exact test

Table 4.32: Associations between average/poor general health and high blood pressure and washing and showering behaviours of the farmers

Variable	Average/poor general health condition			High blood pressure		
	Very good/good (n=107)	Average/ Poor (n=43)	P value	Yes (n=22)	No (n=128)	P value
Change into clean clothes, n (%)			0.07 [a]			1.00 [b]
Right away	89 (83.2)	30 (69.8)		18 (81.1)	101 (78.9)	
Later at the end of the day	18 (16.8)	13 (30.2)		4 (18.2)	27 (21.1)	
Shower after spraying pesticide, n (%)			0.10 [a]			0.25 [a]
Right away	67 (62.6)	33 (76.7)		17 (77.3)	83 (64.8)	
Later at the end of the day	40 (37.4)	10 (23.3)		5 (22.7)	45 (35.2)	
Wash hand/arm after spraying pesticide, n (%)			1.00 [b]			1.00 [b]
Right away	106 (99.1)	43 (100)		22 (100)	127 (99.2)	
Later at the end of the day	1 (0.9)	0 (0.0)		0 (0.0)	1 (0.8)	

[a] P value Chi-Square test, [b] P value by Fisher Exact test

Table 4.33: Associations between somatic and neuropsychiatry symptoms and washing and showering behaviours of the farmers

Variable	Somatic symptoms		Parkinsonism/neurology symptoms		Depression symptoms		Dementia	
	Not Bothered (n=79)/ Bothered at all (n=71)	P value	Not Bothered (n=123)/ Bothered at all (n=27)	P value	Not Bothered (n=136)/ Bothered at all (n=14)	P value [b]	Not Bothered (n=126)/ Bothered at all (n=24)	P value
Change into clean clothes, n (%)		0.79 [a]		0.76 [a]		0.49		0.41 [b]
Right away	62 (78.5)/ 57 (80.3)		97 (78.9)/ 22 (81.5)		109 (80.1)/ 10 (71.4)		98 (77.8)/ 21 (87.5)	
Later at the end of the day	17 (21.5)/ 14 (19.7)		26 (21.1)/ 5 (18.5)		27 (19.9)/ 4 (28.6)		28 (22.2)/ 3 (12.5)	
Shower after spraying pesticide, n (%)		0.82 [a]		0.65 [a]		0.78		0.64 [a]
Right away	52 (65.8)/ 48 (67.6)		81 (65.9)/ 19 (70.4)		90 (66.2)/ 10 (71.4)		85 (67.5)/ 15(62.5)	
Later at the end of the day	27 (34.2)/ 23 (32.4)		42 (34.1)/ 8 (29.6)		46 (33.8)/ 4 (28.6)		41 (32.5)/ 9 (37.5)	
Wash hand/arm after spraying pesticide, n (%)		1.00 [b]		1.00 [b]		1.00		1.00 [b]
Right away	78 (98.7)/ 71 (100)		122 (99.2)/ 27 (100)		135 (99.3) /14 (100)		125 (99.2)/ 24 (100)	
Later at the end of the day	1 (1.3)/ 0 (0.0)		1 (0.8)/ 0 (0.0)		1 (0.7)/ 0 (0.0)		1 (0.8)/ 0 (0.0)	

[b] P value by Chi-Square test, [b] P value by Fisher Exact test

Table 4.34: Associations between average/poor general health and high blood pressure and repairing and cleaning equipment after spraying by the farmers

Variable	Average/poor general health condition			High blood pressure		
	Very good/good (n=107)	Average/ Poor (n=43)	P value	Yes (n=22)	No (n=128)	P value
Repair spraying or mixing equipment, n (%)			0.10 [a]			0.25 [a]
Yes	67 (62.6)	33 (76.7)		17 (77.3)	83 (64.8)	
No	40 (37.4)	10 (23.3)		5 (22.7)	45 (35.2)	
Wash equipment after pesticide use, n (%)			0.07 [a]			1.00 [b]
Yes	89 (83.2)	30 (69.8)		18 (81.8)	101 (78.9)	
No	18 (16.8)	13 (30.2)		4 (18.2)	27 (21.1)	
Frequency clean spraying equipment (n=119), n (%)			0.27 [a]			0.41 [b]
Always	23 (25.8)	5 (16.7)		4 (22.2)	24 (23.8)	
Most of the times	12 (13.5)	7 (23.3)		5 (27.8)	14 (13.9)	
Half of the times	5 (5.6)	0 (0.0)		0 (0.0)	5 (5.0)	
Sometimes	49 (55.1)	18 (60.0)		9 (50.0)	58 (57.4)	
Place clean spraying equipment (n=119), n (%)			0.78 [a]			0.79 [a]
Farm	66 (74.2)	23 (76.7)		13 (72.2)	76 (75.2)	
Home	23 (25.8)	7 (23.3)		5 (27.8)	25 (24.8)	
Activity when clean spraying equipment (n=119), n (%)			0.57 [b]			0.57 [b]
Hose down the sprayer	3 (3.4)	0 (0.0)		0 (0.0)	3 (3.0)	
Clean nozzle	2 (2.2)	1 (3.3)		0 (0.0)	3 (3.0)	
Rinse tank	84 (94.4)	29 (96.7)		18 (100)	95 (94.0)	
Material used to clean the equipment (n=119), n (%)			0.37 [b]			0.32 [b]
Sand only	0 (0.0)	1 (3.3)		0 (0.0)	1 (1.0)	
Water only	76 (85.4)	26 (86.7)		18 (100)	84 (83.1)	
Water and soap	12 (13.5)	3 (10.0)		0 (0.0)	15 (14.9)	
Cleaning agent	1 (1.1)	0 (0.0)		0 (0.0)	1 (1.0)	

[a] P value by Chi-Square test, [b] P value by Fisher Exact test

Table 4.35: Associations between somatic and neuropsychiatry symptoms and repairing and cleaning equipment after spraying by the farmers

Variable	Somatic symptoms		Parkinsonism/neurology symptoms		Depression symptoms		Dementia	
	Not Bothered (n=79)/ Bothered at all (n=71)	P value	Not Bothered (n=123)/ Bothered at all (n=27)	P value	Not Bothered (n=136)/ Bothered at all (n=14)	P value [b]	Not Bothered (n=126)/ Bothered at all (n=24)	P value
Repair spraying or mixing equipment, n (%)		0.82 [a]		0.65 [b]		0.78		0.64 [a]
Yes	52 (65.8)/ 48 (67.6)		81 (65.9)/ 19 (70.4)		90 (66.2)/ 10 (71.4)		85 (67.5)/ 15(62.5)	
No	27 (34.2)/ 23 (32.4)		42 (34.1)/ 8 (29.6)		46 (33.8)/ 4 (28.6)		41 (32.5)/ 9 (37.5)	
Wash equipment after pesticide use, n (%)		0.79 [a]		0.76 [b]		0.49		0.41 [b]
Yes	62 (78.5)/ 57 (80.3)		97 (78.9)/ 22 (81.5)		109 (80.1)/ 10 (71.4)		98 (77.8)/ 21 (87.5)	
No	17 (21.5)/ 14 (19.7)		26 (21.1)/ 5 (18.5)		27 (19.9)/ 4 (28.6)		28 (22.2)/ 3 (12.5)	
Frequency clean spraying equipment (n=119), n (%)		0.51 [b]		0.04 [b]		0.71		0.54 [b]
Always	16 (25.8)/ 12 (21.1)		22 (22.7)/ 6 (27.3)		25 (22.9)/ 3 (30.0)		24 (24.5)/ 4 (19.0)	
Most of the times	10 (16.1) 19 (15.8)		14 (14.4)/ 5 (22.7)		18 (16.5)/ 1 (10.0)		15 (15.3)/ 4 (19.0)	
Half of the times	1 (1.6)/ 4 (7.0)		2 (2.1)/ 3 (13.6)		4 (3.7)/ 1 (10.0)		3 (3.1)/ 2 (9.5)	
Sometimes	35 (56.5)/ 32 (56.1)		59 (60.8)/ 8 (36.4)		62 (56.9)/ 5 (50.0)		56 (57.1)/ 11 (52.5)	
Place clean spraying equipment (n=119), n (%)		0.79 [a]		0.77 [a]		0.71		0.87 [a]
Farm	45 (75.8)/42 (73.7)		72 (74.2)/17 (77.3)		82 (75.2)/7 (70.0)		73 (74.5)/16 (76.2)	
Home	15 (24.2)/15 (26.3)		25 (25.8)/5 (22.7)		27 (24.8)/3 (30.0)		25 (25.5)/5 (23.8)	
Activity when clean spraying equipment (n=119), n (%)		0.15 [b]		0.07 [b]		0.26		0.56 [b]
Hose down the sprayer	1 (1.6)/2 (3.5)		1 (1.0)/2 (9.1)		2 (1.8)/1 (10.0)		2 (2.0)/1 (4.8)	
Clean nozzle	0 (0.0)/3 (5.3)		3 (3.1)/0 (0.0)		3 (2.8)/0 (0.0)		3 (3.1)/0 (0.0)	
Rinse tank	61 (98.4)/52 (91.2)		93 (95.9)/20 (90.9)		104 (95.4)/9 (90.0)		93 (94.9)/20 (95.2)	
Material used to clean the equipment (n=119), n (%)		0.42 [b]		0.21 [b]		0.01		0.17 [b]
Sand only	0 (0.0)/1 (1.7)		1 (1.0)/0 (0.0)		1 (0.9)/0 (0.0)		1 (1.1)/0 (0.0)	
Water only	56 (88.9)/47 (81.0)		84 (87.5)/19 (82.6)		95 (85.6)/8 (80.0)		84 (84.8)/19 (86.4)	
Water and soap	7 (11.1)/ 9 (15.6)		13 (13.5)/3 (13.0)		15 (13.5)/1 (10.0)		14 (14.1)/2 (9.1)	
Cleaning agent	0 (0.0)/ 1 (1.7)		0 (0.0)/1 (4.4)		0 (0.0)/1 (10.0)		0 (0.0)/1 (4.5)	

[a] P value by Chi-Square test, [b] P value by Fisher Exact test

Table 4.36: Associations between average/poor general health and high blood pressure and pesticide use during first day of current spraying week

Variable	Average/poor general health condition			High blood pressure		
	Very good/ Good (n=107)	Average/ Poor (n=43)	P value [a]	Yes (n=22)	No (n=128)	P value [a]
Number of pesticide(s), n (%)			0.01			0.67
Single pesticide	37 (34.6)	25 (58.1)		10 (45.5)	52 (40.6)	
More than one	70 (65.4)	18 (41.9)		12 (54.5)	76 (59.4)	
Type of pesticide, n (%)						
Insecticide	85 (79.4)	36 (83.7)	0.55	18 (81.8)	103 (80.5)	0.88
Herbicide	17 (15.9)	12 (27.9)	0.09	9 (40.9)	20 (15.6)	0.01
Fungicide	44 (41.1)	9 (20.9)	0.02	6 (27.3)	47 (36.7)	0.39

[a] P value by Chi-Square test

Table 4.37: Associations between somatic and neuropsychiatry symptoms and pesticide use during first day of current spraying week

Variable	Somatic symptoms		Parkinsonism/neurology symptoms		Depression symptoms		Dementia symptoms	
	Not Bothered (n=79)/ Bothered at all (n=71)	P value [a]	Not Bothered (n=123)/ Bothered at all (n=27)	P value [a]	Not bothered (n=136)/ Bothered at all (n=14)	P value [a]	Not Bothered (n=126)/ Bothered at all (n=24)	P value [a]
Number of pesticide(s), n (%)		0.12		0.72		0.65		0.97
Single pesticide	28 (35.4)/ 34 (47.9)		50 (40.7)/ 12 (44.4)		57 (41.9)/ 5 (35.7)		52 (41.3)/ 10 (41.7)	
More than one	51 (64.6)/ 37 (52.1)		73 (59.3)/ 15 (55.6)		79 (58.1)/ 9 (64.3)		74 (58.7)/ 14 (58.3)	
Type of pesticide, n (%)								
Insecticide	68 (86.1)/ 53 (74.6)	0.08	102 (82.9)/ 19 (70.4)	0.14	110 (80.9)/ 11 (78.6)	0.74	102 (81)/ 19 (79.2)	0.84
Herbicide	13 (16.5)/ 16 (22.5)	0.35	20 (16.3)/ 9 (33.3)	0.04	26 (19.1)/ 3 (21.4)	0.74	24 (19.0)/ 5 (20.8)	0.84
Fungicide	25 (31.6)/ 28 (39.4)	0.32	41 (33.3)/ 12 (44.4)	0.27	46 (33.8)/ 7 (50)	0.23	44 (34.9)/ 9 (37.5)	0.81

[a] P value by Chi-Square test

Table 4.38: Associations between average/poor general health and high blood pressure and pesticide exposure

Variable	Average/poor general health			High blood pressure		
	Very good/ Good (n=107)	Average/Poor (n=43)	P value	Yes (n=22)	No (n= 128)	P value
EFS score			0.01 [a]			<0.01 [a]
Median (Q1-Q3)	163. 3 (113.1-241.9)	108.9 (62.6-201.5)		108.9 (82.2-151.1)	163.3 (108.9-251.7)	
AHS score			0.22 [a]			0.08 [a]
Median (Q1-Q3)	2.4 (2.3-2.8)	2.4 (2.4-2.8)		2.4 (2.4-3.5)	2.4 (2.3-2.8)	
DREAM scores (n=130)			0.24 [a]			0.90 [a]
Median (Q1-Q3)	70.4 (39.0-112.6)	86.7 (41.7-132.5)		86.7 (39.2-117.8)	70.4 (40.8-122.5)	
Level of urinary metabolites (n=25), n (%)			0.38 [b]			0.48 [b]
High /Very high	10 (55.6)	2 (28.6)		0 (0.0)	12 (52.2)	
Minimal/Low	8 (44.4)	5 (71.4)		2 (100)	11 (47.8)	

[a] P value by Mann- Whitney U test, [b] P value by Fisher Exact test

Table 4.39: Associations between somatic and neuropsychiatry symptoms and pesticide exposure

Variable	Somatic symptoms		Parkinsonism/neurology symptoms		Depression symptoms		Dementia symptoms	
	Not Bothered (n=79)/ Bothered at all (n=71)	P value	Not Bothered (n=123)/ Bothered at all (n=27)	P value	Not Bothered (n=136)/ Bothered at all (n=14)	P value	Not Bothered (n=126)/ Bothered at all (n=24)	P value
EFS score		0.93 [a]		0.60 [a]		0.69 [a]		0.82 [a]
Median (Q1-Q3)	154.0 (104.6-217.8)/ 133.3 (108.9-251.9)		153.6 (104.6-241.9)/ 133.3 (108.9-209.4)		151.1 (104.6-230.8)/ 173.1 (108.9-251.9)		151.1 (103.7-244.0)/ 142.2 (108.9-206.5)	
AHS score		0.97 [a]		0.08 [a]		0.29 [a]		0.15 [a]
Median (Q1-Q3)	2.4 (2.4-2.8)/ 2.4 (2.4-2.8)		2.4 (2.4-2.5)/ 2.4 (2.4-3.5)		2.4 (2.4-2.8)/ 2.4 (2.4-3.1)		2.4 (2.4-2.8)/ 2.4 (2.4-3.6)	
DREAM scores (n=130)		0.86 [a]		0.75 [a]		0.40 [a]		0.71 [a]
Median (Q1-Q3)	71.3 (39.0-122.3)/ 74.3 (40.7-122.8)		70.4 (40.5-121.1)/ 77.1 (37.8-122.5)		74.7 (40.7-123.1)/ 48.6 (37.5-104.4)		74.1 (40.9-120.1)/ 73.2 (37.6-127.2)	
Level of urinary metabolites (n=25), n (%)		0.85 [b]		1.00 [c]		1.00 [c]		1.00 [c]
High /Very high	6 (46.2)/6 (50.0)		11 (47.8)/1 (50.0)		12 (50.0)/0 (0.0)		12 (50.0)/0 (100)	
Minimal/ Low	7 (53.8)/6 (50.0)		12 (52.2)/1 (50.0)		12 (50.0)/1 (100)		12 (50.0)/0 (100)	

[a] P value by Mann- Whitney U test, [b] P value by Chi-Square test, [c] P value by Fisher Exact test

towards significance for having an incident while using pesticide with an OR of 3.06 (95%CI: 0.92, 10.18)>.

Table 4.40: Predictors for average/poor general health among the farmers

Variable	Simple logistic regression		Multiple logistic regression [a]	
	Crude OR (95% CI)	P value	Adjusted OR (95% CI) [b]	P value
Sprayed less than 1 day per week	3.13 (1.44, 6.81)	<0.01	5.22 (1.69, 17.22)	<0.01
Used one type of pesticide	2.63 (1.27, 5.43)	<0.01	1.65 (0.49, 4.53)	0.38
Used fungicide	0.48 (0.22, 0.95)	0.04	0.92 (0.87, 1.09)	0.70

[a] Forward and backward Multiple Logistic Regression model were applied and backward was used for final model, multicolinearity and interaction term were checked and not found, Hosmer-Lemeshow test (p=0.74) was applied to check the model fit

[b] Adjusted with age- Adjusted OR= 1.08, 95% CI (1.01,1.18), BMI- Adjusted OR=0.32, 95% CI (0.11, 0.90), educational level- Adjusted OR= 0.34, 95% CI (0.10, 1.24), age start working- Adjusted OR=0.92, 95% CI (0.80, 1.06), duration work as farmers- Adjusted OR=1.02, 95% CI (0.98, 1.06) and farm size- Adjusted OR=1.04, 95% CI (0.98, 1.13)

Table 4.41: Predictors for high blood pressure among the farmers

Variable	Simple logistic regression		Multiple logistic regression [a]	
	Crude OR (95% CI)	P value	Adjusted OR (95% CI)[b]	P value
Had incident while using pesticide	2.59 (1.01, 6.70)	0.04	4.06 (1.21, 11.66)	0.02
Used herbicide	3.74 (1.41, 9.91)	<0.01	1.45 (0.45, 5.32)	0.38

[a] Forward and backward Multiple Logistic Regression model were applied and backward was used for final model, multicolinearity and interaction term were checked and not found, Hosmer-Lemeshow test (p=0.77) was applied to check the model fit

[b] Adjusted with age- Adjusted OR=1.08, 95% CI (1.02, 1.55) and duration work as farmers- Adjusted OR=0.99, 95% CI (0.96, 1.04)

Table 4.42: Predictors for being bothered at all of Parkinsonism/neurology symptoms among the farmers

Variable	Simple logistic regression		Multiple logistic regression [a]	
	Crude OR (95% CI)	P value	Adjusted OR (95% CI) [b]	P value
Had re- entry into farming area	2.44 (1.02, 5.88)	0.04	3.15 (0.91, 10.94)	0.07
Had incident while using pesticide	3.30 (1.37, 7.96)	<0.01	4.48 (1.46, 13.74)	0.01
Used herbicide	2.58 (1.01, 6.54)	<0.05	2.75 (0.81, 9.37)	0.11
Not used PPE	2.70 (1.11, 6.53)	0.03	1.46 (0.42, 5.08)	0.55

[a] Forward and backward Multiple Logistic Regression model were applied and backward was used for final model, multicolinearity and interaction term were checked and not found, Hosmer-Lemeshow test (p=0.15) was applied to check the model fit

[b] Adjusted with age- Adjusted OR=1.06, 95% CI (1.01, 1.12), income- Adjusted OR=3.10, 95% CI (0.95, 10.07) and duration work as farmers- Adjusted OR=1.02, 95% CI (0.98, 1.07)

Table 4.43: Predictors for being bothered at all of depression symptoms among the farmers

Variable	Simple logistic regression		Multiple logistic regression [a]	
	Crude OR (95% CI)	P value	Adjusted OR (95% CI) [b]	P value
Had incident while using pesticide	3.69 (1.20, 11.33)	0.02	3.06 (0.92,10.18)	0.07

[a] Forward and backward Multiple Logistic Regression model were applied and backward was used for final model, multicolinearity and interaction term were checked and not found, Hosmer-Lemeshow test (p=0.96) were applied to check the model fit
[b] Adjusted with age- Adjusted OR=1.04, 95% CI (1.01, 1.08) and income- Adjusted OR=9.35, 95% CI (1.16, 75.23)

4.2.7.5 Pesticide exposure and somatic symptoms among the farmers

Table 4.44 shows the final model for predictors for being bothered at all by somatic symptoms among the farmers. There were no associations between pesticide exposure and somatic symptoms after adjusted for age and duration work as farmers.

Table 4.44: Predictors for being bothered at all of somatic symptoms among the farmers

Variable	Simple logistic regression		Multiple logistic regression [a]	
	Crude OR (95% CI)	P value	Adjusted OR (95% CI) [b]	P value
Age	1.03 (1.01, 1.05)	0.02	1.00 (0.96, 1.03)	0.40
Duration work as farmers	1.03 (1.01, 1.05)	0.02	1.04 (1.01, 1.07)	0.04

[a] Forward and backward Multiple Logistic Regression model were applied and backward was used for final model, multicolinearity and interaction term were checked and not found, Hosmer-Lemeshow test (p=0.60) was applied to check the model fit
[b] Adjusted with age- Adjusted OR=1.00, 95% CI (0.96, 1.03) and duration work as farmers- Adjusted OR=1.04, 95% CI (1.01, 1.07)

4.2.7.6 Pesticide exposure and dementia symptoms among the farmers

Table 4.45 shows the final model for predictors for bothered at all of dementia symptoms among the farmers. There were no associations between pesticide exposure and dementia symptoms after adjusted for age, age start working and duration work as farmers.

Table 4.45: Predictors for bothered at all of dementia symptoms among the farmers

Variable	Simple logistic regression		Multiple logistic regression [a]	
	Crude OR (95% CI)	P value	Adjusted OR (95% CI) [b]	P value
Age	1.05 (1.01, 1.08)	<0.01	1.08 (1.01, 1.18)	<0.01
Age start working	0.86 (0.74, 0.97)	0.01	0.93 (0.78, 1.06)	0.24
Duration work as farmers	1.03 (1.01, 1.06)	0.01	0.99 (0.95, 1.03)	0.57

[a] Forward and backward Multiple Logistic Regression model were applied and backward was used for final model, multicolinearity and interaction term were checked and not found, Hosmer-Lemeshow test (p=0.71) was applied to check the model fit

[b] Adjusted with age- Adjusted OR=1.08, 95% CI (1.01, 1.18), age start working- Adjusted OR= 0.93, 95% CI (0.78, 1.06) and duration work as farmers- Adjusted OR=0.99, 95% CI (0.95, 1.03)

4.3 DISCUSSION

The main study was successfully conducted among 150 farmers which consist of 83 rice farmers and 67 vegetable/fruit farmers in Bachok and Kota Bharu, Kelantan. The main study protocol which was discussed in Chapter 2 served as standard produced for conducting research work in the context of Malaysia and became a main source of reference throughout the journey. No violation of the protocol was reported by the research team and institutional review board.

This chapter explored the working practises across two type of farming systems in Kelantan and assesses the exposure of pesticide through urine metabolites, pesticide exposure intensity scores by adapting the EFS and AHS algorithms and dermal assessment by using DREAM scores. In addition, it aimed to investigate the association between level of urine metabolites and demographic factors, working practices and exposure to pesticide.

Pesticide exposure is an environmental threat especially among occupationally exposed populations. Hence, this remains major public health interest in the toxic effects of pesticide exposure particularly in terms of effects on hypertension and also somatic and neuropsychiatry symptoms. This present chapter also investigates the effects of pesticide exposure on general health, blood pressure and somatic and neuropsychiatry symptoms.

4.3.1 Principal findings

This study found all of pesticide metabolites except DBVA were detected above level of detection in more than half of the farmers indicate the farmers exposed to it. The difference between pre- and post-spraying metabolites were clearly higher in farmers who used the pesticide and this was not observed among farmers who did not report using the pesticide. The farmers who use power sprayer/blower and exposed head and face had significantly higher level of urinary metabolites.

The rice farmers had significant higher scores using the EFS score and this did not observe on AHS score. DREAM scores indicated significantly higher dermal exposures were obtained during spraying compared to mixing and the scores were higher in rice farmers for spraying and vegetable/fruit farmers for mixing. However, overall DREAM scores for both activities showed no difference between type of farming.

Farmers who reported being bothered at all for high blood pressure, Parkinsonism/neurology and depression but not average/poor health status, somatic and dementia symptoms were more likely to have had an incident while handling pesticides. Famers who reported having average/poor health status were more likely to spraying one day or less per week.

More than half of the farmers reported having very good or good general health status and the most common self-reported medical illness among the farmers was high blood pressure. Nearly half of the farmers were bothered at all of somatic symptoms and among neuropsychiatry symptoms, Parkinsonism/neuropathy symptoms were the most common symptom (18.0%) compared to dementia (16.0%) and depression (9.3%).

4.3.2 Possible explanations for findings

More than 50.0% of the farmers had detectable levels of six out of seven metabolites namely bifenthrin, cDCVA, DBVA, 3PBA, 356TCP, tDCVA and total DCVA. The pre-spraying urine samples had detected levels of these metabolites in the majority of the farmers. The pre-spraying sample were collected at least seven days before the first day of spraying and hence, it is less likely that the presence of metabolites in the pre-use sample was due to direct use of the pesticide. Possible reasons for the pre-spraying sample having detectable levels of pesticide metabolites include non-occupational exposure such as take home exposure on clothes, inhalation of pesticide beyond the spraying area, the residential area near the agricultural lands and also dietary contamination by pesticide (86).

A similar pattern was observed in the percentage of detectable levels for 356TCP and 3PBA among farmers in Thailand, where the percentage was 76.5% and 86.8%, respectively (175). Urine concentrations of most metabolites varied greatly among farmers and the most striking findings were among farmers who used pyrethroid, chlorpyrifos and cypermethrin, there were differences between pre- and post-spraying urine samples. However, this was not observed among farmers who did not used specific pesticides. Furthermore, the difference in pre- and post-spraying levels of cDCVA, 3PBA, 356TCP, tDCVA and total DCVA were observed between farmers who had used pyrethroid, chlorpyrifos and cypermethrin and who had not used the pesticide.

An interesting observation is that the farmers who used power sprayers/blowers had higher levels of urinary metabolites. This finding is not surprising as power sprayers/blowers are high pressure devices which may expose farmers to higher levels of pesticides compared to backpacker sprayers (176). In addition, the farmers whose head or face was exposed had higher level of urinary metabolites. This is possible due low percentage used of PPE to cover head or face. Due to small samples size, the remaining variables did not show any statistically significant results.

Accurate exposure assessment is important in order investigate the potential adverse health effects among occupationally exposed population (177). The results from this study provide a step forward in the estimation of pesticide exposure. There is currently no gold standard for assessing pesticide exposure. In the absence of a direct comparison, more indirect measures were used to assess pesticide exposure such as PEIs. In this study those PEIS from the AHS and EFS were used. The AHS has been validated with urinary biomarker concentration in two other farming populations, the Pesticide Exposure Assessment Survey (PEAS) in Ontario, Canada and the Farm Family Exposure Study (FFES) in Minnesota and South Carolina. The AHS is based upon large scale farming in the USA. Whereas the EHS PEI comes from low scale farming that is more comparable to the Malay experience but has not been validated. Hence, neither the EFS nor AHS PEI is ideal. This study found significant difference in EFS scores compared to AHS scores between farmers. The difference of EFS score was mainly driven by difference in amount of pesticide use among the farmers, which was included in EFS but not the AHS algorithm and also due to Malaysian farming system being likely more similar to that in Ethiopia compared to the USA. In addition, the exposure modifying factors are different in EFS and AHS algorithms.

This study also focused on dermal exposure assessment to pesticides which is the predominant route of entry for occupational pesticide exposure and DREAM scores were used to assess dermal pesticide exposure. The DREAM scores resulting from this study showed that the dermal contamination is dependent on the task of farmers, being higher during pesticide spraying. However, typically the mixing and loading tasks were associated with greatest intensity of pesticide exposure compared to spraying (54).

Another interesting finding was that during mixing, dermal contamination was higher among vegetable/fruit farmers compared to rice farmers and that during spraying dermal contamination was higher among rice farmers compared to vegetable/fruit farmers. These differences could be because the difference in spraying equipment, PPE used, and working practices during mixing and spraying and environmental conditions between type of farming. During mixing, the hands were more exposed compared to body especially among vegetable/fruit farmers. This could be because during mixing, the farmers used bare hands to hold cup and pour the pesticide to the sprayer. Hence, the exposure was high. However, during spraying, the body was more exposed compared to hands especially among rice farmers. It seems that the explanation could be that during spraying, the body was exposed more to droplet of pesticides than hands.

The DREAM scores for bodies during mixing and hands for spraying were 0 and these scores were driven by the majority of the farmers being exposed occasionally and to small amounts (<10% of hands or body parts) of pesticide. This was also consistent with the recorded videos where the bodies and hands of many of the farmers were not exposed to pesticide during mixing and spraying, respectively. Based on three studies, none of them examined DREAM scores by individual components such as hands or other body parts and type of activities (124-126). In a study conducted by Udin et al, the results did not mention the type of activities and divided the result based on potential dermal and actual dermal exposure of body parts and type of farming (124). In another study conducted by Agostine et al, the results were divided based on potential and actual dermal exposure for hands and body parts (125). In a study conducted by Van Wendel de Joode et al, the results were divided based on potential and actual dermal exposure and type of farming (126).

The majority of the farmers are considered fairly old or ageing. There is a trend in Malaysia where increasingly young people are leaving rural areas and migrating to the cities to get a job in the service or industrial sectors. Duration of working of farmers provides some information on the degree of exposure to pesticide. In this study, the median duration of working as a farmer was 20 years which indicates they are experienced farmers and also maybe they exposure to pesticides chronically. Nearly all of the farmers were farm owners and involved in all tasks e.g. dilution, mixing, preparation and application. This is customary in small agricultural practices and often the farm belongs to their family where specialised work is less required (48,178). The median farm size among the farmers was considered high compare to the national average which was 3.7 acres (179). There was a statistically significant difference between types of farm activity, where median farm size of rice farmers was eight acres compared to the two acres of vegetable/fruit farmers. This is almost similar to the farm size of rice farmers in Laguna, The Philippine (7 acres) and Sindh, Pakistan (4 acres) (180). Because of the larger farm size, rice farmers spend more time doing spraying tasks either per day and week compared to vegetable/rice farmers.

The majority of the farmers used backpacker sprayers which are considered suitable and practical by small scale farmers who do not require large boom sprayers like large scale farmers. In addition, it is cost effective, easy to fill and comfortable to operate (181). The number of rice farmers who worked in field while someone else sprays and who were involved in incidents were higher compared to vegetable/fruit farmers. This is probably due to the large size of the rice farms which can result in more pesticide exposure and due to rice farmers sharing the same field with others which can increase the probability of having an incident.

Half of the farmers stored pesticides in garages near their house because of the absence of a proper place to store pesticides on their fields. However, this storage technique is unsafe because of the risk of cross contamination. Best practice is to kept pesticides on the fields to prevent residential exposure. A small portion of the farmers stored pesticides in their own homes. This is a common practice in developing countries (182). This practice may result in their family being exposed and the containers may also be easily reached by small children. This will also potentially increase the risk of self-harm attempts and suicides among the farmers and their family members which include small children (183) .

The majority of the farmers in this study population were exposed to two or more types of pesticides. In addition, the number and type of pesticides used among the farmers were broad. This is probably because of the broad range of crops cultivated by the farmers which required them to use different pesticides. This practice is also influenced by previous crop yields experienced by the farmers. Moreover, this can save on labour costs for them. Unfortunately, this practice will increase concentration of active ingredient of pesticide. Thereby, increasing the risk of health effects to pesticide among farm workers.

This study found that farmers frequently used moderately or slightly hazardous pesticides belonging to the WHO Hazard Classification II. Figure 4.9 shows example of the WHO Hazard Classification II pesticide used by the farmers. This finding is not surprising and is similar to another study conducted in another part of Malaysia, Tanjung Karang (44) and also in Kuwait (184). This could be because the Malaysia government has banned or restricted use of pesticide class I and the majority of the farmers used pesticides subsidised by the government. This finding is different from those reported by other studies in other developing countries such as Thailand (175) where the farmers used Class IB pesticides, Sri Lanka (185) where farmers used 50% class I and class II pesticides, and Pakistan (186) and Mexico (187) where class IA and IIB pesticides still being used extensively.

Figure 4.9: Example of pesticide (chlorpyrifos and cypermethrin- WHO Classification II) used by the farmers

Insecticides were the highest share of total pesticides used among the farmers. Figure 4.10 shows the example of insecticide used by the farmers. The higher consumption of insecticides was probably due to the tropical climate which was warm and humid and provides favourable breeding environments for insects. This result is similar to that observed in studies conducted in other parts of Malaysia (188), Turkey (189) and other developing countries like India (190), Vietnam (191) and Indonesia (192).

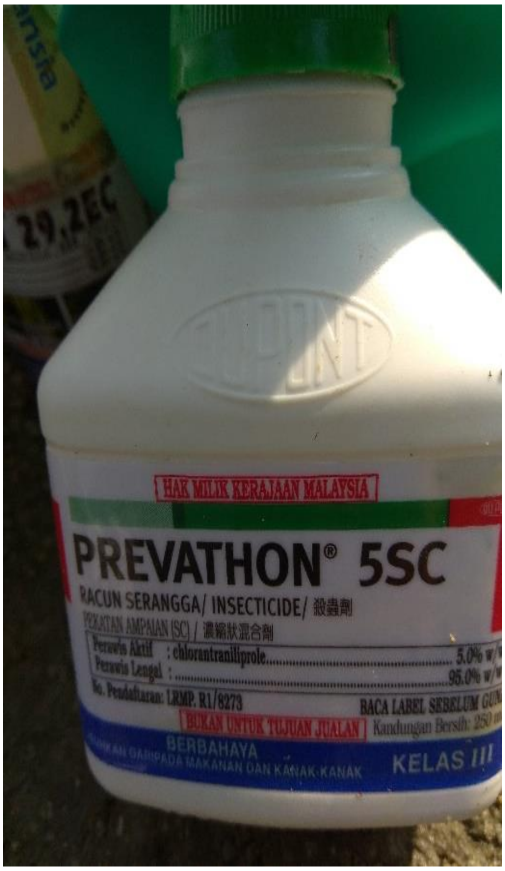


Figure 4.10: Example of insecticide used by the farmers

As explained in chapter 1, the rate of dermal absorption differs depending upon the anatomical parts of the body. This study found that, hands, head and forearms were the most frequent body parts that were in contact with pesticides and which could be a potential site of exposure of pesticides. The findings were in alignment with a study conducted among farmers in France (51,59,60). It is likely because most of the farmers did not used protective clothes such as gloves, masks and long sleeve shirts to cover that body part (Figure 4.11). In addition, hands were more exposed because of the high possibility of leakage from the sprayer lance, handle or hose. This may lead to higher exposure to pesticide especially via dermal pathway.

Many studies in developing countries such as in Indonesia and South Africa showed that farm workers have deficiencies in occupational personal hygiene (193–195). Examples include careless handling during preparation and spraying, lack of PPE use, empty pesticide containers disposal, eating and drinking while working and lack of personal hygiene. Clothes that were worn during pesticide handling might become contaminated and the body absorbs the pesticides and hence increased exposure. With regard to personal hygiene measures, the majority of the farmers reported cleaning clothes, washing hands or arms and showering right away after pesticide handling. This finding is similar to that reported in Nigeria, India and Malaysia where nearly all the farmers washed their hands and changes clothes right away after pesticide application (196–198). Several explanations are possible including the farmers' farms being near to the house which makes it easier for the farmers to perform the task. This good behaviour is crucial to reduce risk of contamination to themselves and well as to family members.

Figure 4.11: The farmer did not used gloves while mixing the pesticide

The majority of the vegetable/fruit farmers washed their equipment after pesticide use. One explanation for this striking finding could be that to prevent cross-contamination of pesticides especially among vegetable and fruit farmers where majority of them sprayed more than one crops with difference type of pesticides. Other possibilities are to prevent sprayer corrosion by pesticides and to prepare for the next job. Nearly all of the vegetable/fruit farmers repaired the equipment, possibly because nearly all the vegetable/fruit farmers used backpack sprayers which are easy to repair.

The use of PPE could reduce direct contact of the pesticide with the skin or via inhalation potentially reducing health problems among farmers. Although some of the farmers may be aware of the importance of using PPE, farmers were often not compliant possibly because the hot tropical climate made it difficult for farmers to breathe properly through mask. PPE also is not available due to poverty and its high cost or lack of training programs by the government (133,199,200). This will lead to lack of effective protection for farm workers against pesticide exposure during handling of pesticides. Many of the farmers did not used proper masks and they prefer to use scarf or normal shirts to cover their face, which is culturally a part of local attire to protect their head and face from sun exposure and is more comfortable (Figure 4.12). Unfortunately, this is not an effective way to protect them when applying pesticide as it made of thin cotton and could be easily penetrated by deposited pesticides.

Figure 4.12: The rice farmer used scarf to cover head and face

A few studies have observed pesticide exposure to be associated with increase blood pressure (201–204). Similarly, this study found that farmers who had incident while using pesticide had a higher chance of having self-reported high blood pressure. Although acute health effects to brain function have been well described, there has been more controversy on the chronic neurotoxic effects, especially of low-level pesticide exposure (154). This study also found that Parkinsonism was associated with pesticide exposure during incident such as leakage or spillage of pesticide. A systematic review and meta-analysis were conducted in 2012 by Van Maele-Fabry et al. to examine the association between occupational pesticide exposure and Parkinson's disease (PD) (205). Twelve cohort studies were included in this review, with most of the studies examining exposure to pesticides in general. Eight studies assessed exposure by using surrogate markers of exposure and six studies used self-reported exposure. There was evidence of increased risk of PD observed when all the studies were combined when the meta rate ratio was 1.28 (95% CI; 1.03, 1.59). In conclusion, the review suggesting that pesticide exposure increases the risk of PD.

This study found that depression also associated with pesticide exposure during incident while handling pesticide. In a systematic review conducted by Freire et al. in 2013 to examine the association between pesticide exposure and depression (206). In this review, 11 studies, six were cross-sectional, three case-control and two ecological studies. All of the studies examined exposure to the mixing of pesticides. Seven studies assessed exposure by self-report or surrogate markers of exposure in three studies or by the use of blood AChE in one study. However, results were inconsistent when only five studies showed a significantly increased risk of depression following pesticide exposure with OR (95% CI) ranging from 2.08 (1.16, 3.72) to 5.95 (2.56, 13.84). This systematic review suggests that pesticide exposure potentially may be associated with an increased risk of depression and hence results from this study are consistent with the systematic review.

In this present study, dementia was not associated with pesticide exposure. In a systematic review and meta-analysis conducted by Yang et al. in 2016 to examine the association between occupational pesticide exposure and Alzheimer disease (AD) (207). In total, seven studies were included in this review and three were cohort and four case-control studies. All of the studies examine exposure to mixing of pesticides and assessed exposure by using self-report. Meta-analysis showed that there was a positive association between pesticide exposure and AD (OR=1.34, 95 CI%=1.08, 1.67). Overall, this was evidence of an increased risk of AD among occupationally exposed to pesticides.

Prolonged hypertension will lead to cardiovascular diseases which causes a significant burden to Malaysia as it is the third leading cause of death accounting for 7.8% of total deaths in 2018 (208). The prevalence of high blood pressure in this study was 14.7%. This is consider low compare to a national prevalence of 35.3% (209). The present study was the second study conducted in a similar setting in which the first study was conducted in 2010 ,where 30.8% of the farmers reported having hypertension (133). Having said that, the sample size in the previous study was low (n=39) and so results from it may not represent the exact prevalence.

Thirteen of the farmers reported somatic health symptoms mainly related to muscle pain such as back, arm, legs or joint pain. One explanation of this is, probably due to perception because of heavy work carried out for a long time under high temperature. Having said that, stress factors associated with somatic symptoms cannot be ruled out.

4.3.3 Strengths and weaknesses of the study

This compressive analysis of exposure of pesticide has much strength. Firstly, this study used wide ranging questions for characterizing exposure to pesticide which included working practices and also conditions of hygiene during exposure. Secondly, the compliance with the study was excellent with all the farmers who agreed to participate completing this study. Thirdly, this study looked at a variety of farm types (rice vs. vegetable/fruit) in Malaysia, so that the exposure to pesticides among different types of farming could be estimated and investigated. Fourthly, this study looked extensively at the practice of pesticide use not only during pesticide handling but also before and after use. As a result, this will provide better understanding on practices in Malaysia, which is different than that in developed countries such as in the UK and the USA. The population of this study was from small scale agricultural communities in which the majority of the farmers had completed more than 12 years of education. This generally shows that the literacy rate of participating farmers was acceptable. This also reflects a fairly educated community and the likelihood that they understand correct working practices are better. This study also used interview led questionnaires, so reducing the burden to the farmers in answering the questions and subsequently increasing the response rate. In addition, this will ensure the questions were answered correctly and avoided any missing data.

This study also combined pesticide exposure intensity algorithm scores, DREAM scores and biomonitoring during spraying, so as to provide a better understanding of pesticide exposure. The exposure algorithm allows the assessment of pesticide among farmers in a way which is simple, easily accessible and adapted and economical way especially in developing countries where the budget is limited. This study also adapted pesticide exposure intensity algorithms which were developed for large scale farming in a developed country and also small-scale farming in developing country.

To my knowledge, there are no specific studies reporting urine metabolites as biomarkers of pesticide exposure in Malaysia. Analysis of urine metabolites could be a powerful tool for human biomonitoring. Urine samples have a number of advantages over blood samples as their collection is non-invasive and relatively easy and they can be obtained in large quantities. The urinary metabolites were analysed with the presence of an unexposed group. This can provide reference data on the level of urinary metabolites among unexposed populations which is still not available in Malaysia. This study also measured a number of metabolites and has enabled us to get a wider range of exposure information and having selective metabolites can help in better understanding exposure to specific pesticides.

This current study has several limitations that warrant further discussion. Even though the farmers in this study population come from different types of farming, all of them were small scale farmers. Thereby, this limits comparability with large scale farmers who may have different working practices. The working practices data were collected by means of questionnaire, thus incurring the possibility of self-reported bias due to an inability of the farmers to recall and give the correct answers. Despite these concerns, questionnaires are commonly used because they are feasible and inexpensive especially in resource poor nations with limited financial and logistical resources. Another concern is regarding the sampling method. This study used convenience sampling. Hence, the sample may not be representative of all farmers in Malaysia and this study may have limited generalisability because the study population were men from one state only. The question used to ask whether the farmers used PPE was very general via a single dichotomised question (yes or no). Thus, this study was unable to provide more accurate information on PPE use. In addition, the farmers from this study were exposed to wide range of pesticides which limited the sensitivity of the results. Analysis of determinants of urinary pesticide metabolites was limited due to small sample size and hence, the significance of the results is limited. Thus, regression could not be used to model potential confounding effects of variables. A single spot urine was used because it is more practical compared to multiple collections as the latter are more costly and more of a burden to the farmers and researchers. However, to achieve better accurate results 24 hours urine samples are required (175,210,211).

Many of the studies carry out observation in order to complete the DREAM questionnaire but none of the studies reported the duration of observation or the time for videoing (62)(212)(213)(214). Due to practical reasons, the start of each activity was recorded for only 5 to 10 minutes. For pesticide mixing, this was sufficient as it covered the entire process which usually took not more than two minutes. Pesticide spraying often lasted greater than one hour and it was not possible to record for such a long time. However, the representativeness of the practices observed at the start of the activity may be an issue because the practice may become worse with increasing time and this may lead to measurement errors. Having said that, even though the duration of videoing was 5 to 10 minutes, bad practices such as spraying into the wind were observed.

The study population in this study were farmers who were exposed to pesticides. Based on the systematic literature review in Section 1.6.1 to examine the association between acute ill health effects and pesticide exposure, the study population in 11 out of 16 studies were all exposed to pesticides and the remaining five studies included an unexposed group. Hence, it was decided to recruit farmers who were exposed to pesticides but the possibility of using an unexposed cohort was discussed when the study was designed. It was felt that it would be difficult to identify a group of individuals that were comparable to farmers except for not being exposed to pesticides ie the risk factor under study. So, in this study, there is no unexposed group because of difficulty to identify the population of similar demographics to the farmers. However, it was anticipated that within the population of farmers there would be differences in exposure and hence enable a comparison could be made between farmers with high and low exposure. The advantages of using only an exposed group were that it was easier and more practical to recruit participants with disadvantages including being susceptible to bias as there was no unexposed group. Another possible disadvantage is potential selection bias due to farmers being exposed to various exposure routes such as from take home exposure, bystander exposure or re-entry effect (215).

Another limitation is the diagnosis of blood pressure is based on self-report and not based on standardized methods to measure blood pressure. This will lead to misclassification bias where the farmers are misclassified with regard to high and normal blood pressure.

4.3.4 Potential implications and future research

The results from this study have potential implications for clinicians or policymakers and future research. Health care providers can play a role in raising awareness about the effects of pesticides. Hence, health care providers especially in primary care need to be aware of the occupational health risks related to pesticide exposure especially if they are serving populations at risk for pesticide exposure. When they have fundamental knowledge in this area, they can help the farmers by giving information about the risk of pesticide exposure and also how to manage effectively if the farmers experience an incident due to pesticide such as splash.

Training and monitoring on safe pesticide use and handling could be another promising option and useful for reducing the risks from pesticides. Future studies need to include large scale farmers as well. By selecting different types of farming areas and including both large- and small-scale farmers, a better understanding of working practices and exposure to pesticides will be obtained. Even though this study focuses on occupationally exposure to pesticides exclusively in men, women and children of the farmer's family are also at risk of pesticide exposure. Thus, future research should look at the take home exposure to the farmer's family so as to provide a more comprehensive estimate of exposure to the farmer's family. To reduce potential bias, a future study should consider using an unexposed or referent group that differs in the exposure of interest but is similar as possible with respect to other factors.

The findings from this study need further confirmation from future studies on the chronic effects of pesticide exposure, as the number of farmers who reported symptoms based on published definitions was low, and hence the results should be interpreted with caution. Measurement of blood pressure by using sphygmomanometer is a widely accepted technique of determine the blood pressure and provides a more reliable measurement than self-reported high blood pressure as was used in this study. Hence, future studies need to use this method in order to identify farmers who were previously diagnosed with high blood pressure but also those who are newly diagnosed with high blood pressure.

4.4 CONCLUSION

The present chapter provides comprehensive scientific evidence on exposure to pesticides. In conclusion, the farmers in study were exposed to pesticides as demonstrated by detectable urinary metabolites and increased levels of urinary metabolites were positively associated with use of power sprayers/blowers and also exposure to head and face. The DREAM scores showed higher dermal exposure during spraying compared to mixing. The result from this study provides a step forward in the estimation of pesticide exposure and this finding suggests a unique opportunity to highlight the need for development of public health interventions and implemented.

CHAPTER 5: KNOWLEDGE AND PRACTICE OF PESTICIDE USE AMONG FARMERS AND ASSOCIATED FACTOR FOR KNOWLEDGE, PRACTICE AND PPE USE

5.1 INTRODUCTION

Farmworkers are a high-risk group to be affected by pesticides because their job tasks involve using pesticides. Dermal exposure is the most important route of entry of pesticides especially among farm workers. The use of PPE has been shown to reduce the absorption of pesticides and significantly reduce the urinary herbicide level in pesticide users (46). Therefore, the proper use of PPE is considered an important factor associated with reduced pesticide exposure (48). Knowledge and practice of pesticide use is one of the cornerstones in reducing pesticide exposure (216). Thus, adequate knowledge is a powerful tool to promote more positive attitudes and safe working practices.

There is little information available on PPE use and knowledge and practice of pesticide use in Malaysia, a multicultural nation with great ethnic diversity. Studies involving palm oil workers carried out in Sabah, Malaysia documented positive results with more than 70.0% of respondents having a good level of pesticide handling knowledge as well as good attitudes and practices (217). Another study conducted in a different state in Malaysia, Johor among palm oil workers showed that only 25.0% of the respondents had a good knowledge of pesticide use, the practice of 75.0% of the respondents was good (218).

Thus, evaluating PPE use and knowledge and practice can help in designing appropriate interventions for the management and prevention strategies to reduce pesticide exposure. In addition, such results also provide baseline or reference information and data to evaluate the success of prevention strategies. In addition, such studies can help to identify existing gaps in good pesticide management practices and safety in the state and by extension the entire country.

5.1.1 Aims and objectives

The overall aims of the work described in this chapter were to determine the knowledge and practice of pesticide use among the farmers and determinants of the knowledge and practice of pesticide use as well as PPE use.

The specific objectives were to

a) Assess knowledge and practice of pesticide use among the farmers
b) Determine the associations between knowledge and practice of pesticide use and demographics, working practices during previous spraying sessions and pesticide use during the first day of current spraying week
c) Determine the associations between PPE use and demographic, working practices during previous spraying sessions and pesticide use during the first day of current spraying week

5.2 RESULTS

The study population in this chapter was the same as that of Chapter 4 and consisted of 150 farmers.

5.2.1 Level of knowledge and practice of pesticide use

Figure 5.1 shows the distribution of knowledge scores of pesticide use. The calculation of knowledge score has been explained in Section 2.8 (Table 2.2). The median and Q1-Q3 level of knowledge among farmers was 10.0 and 8.0-10.0, respectively.

Figure 5.2 showed the distribution of practice score of pesticide use. The calculation of practice score has been explained in Section 2.8 (Table 2.2). The median and Q1-Q3 practice level score among farmers was 52.0 and 50.0-55.0, respectively.

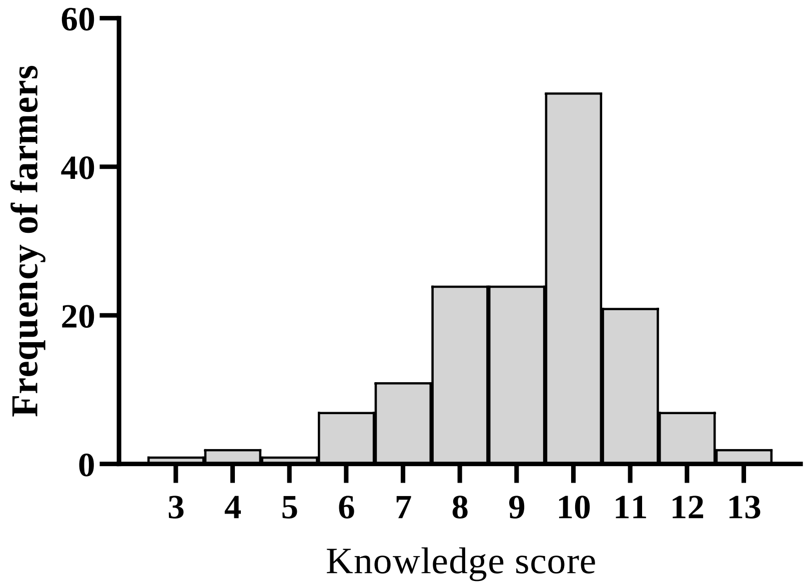


Figure 5.1: Distribution of knowledge score of pesticide use

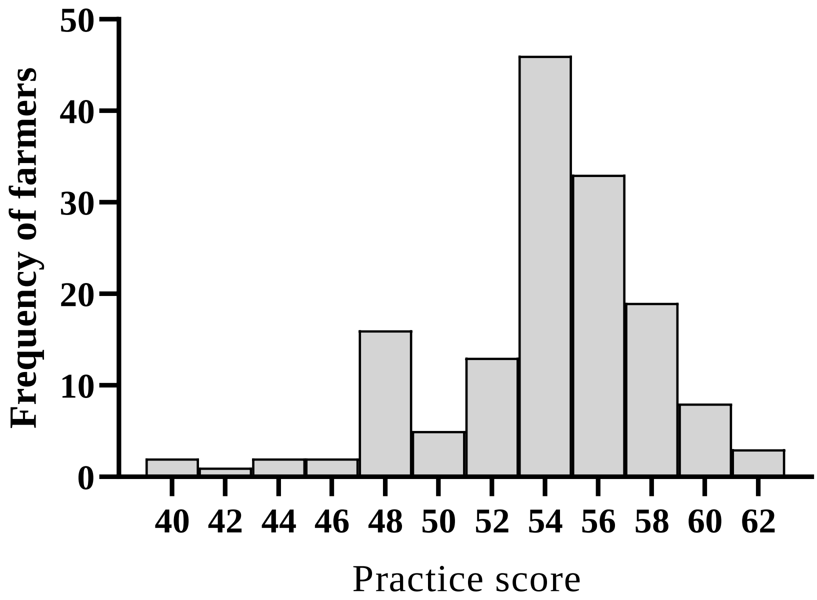


Figure 5.2: Distribution of practice score of pesticide use

Figure 5.3 shows the correlation between knowledge and practice score of pesticide use. The correlation revealed a weak significant positive linear correlation between knowledge and practice score ($p<0.01$).

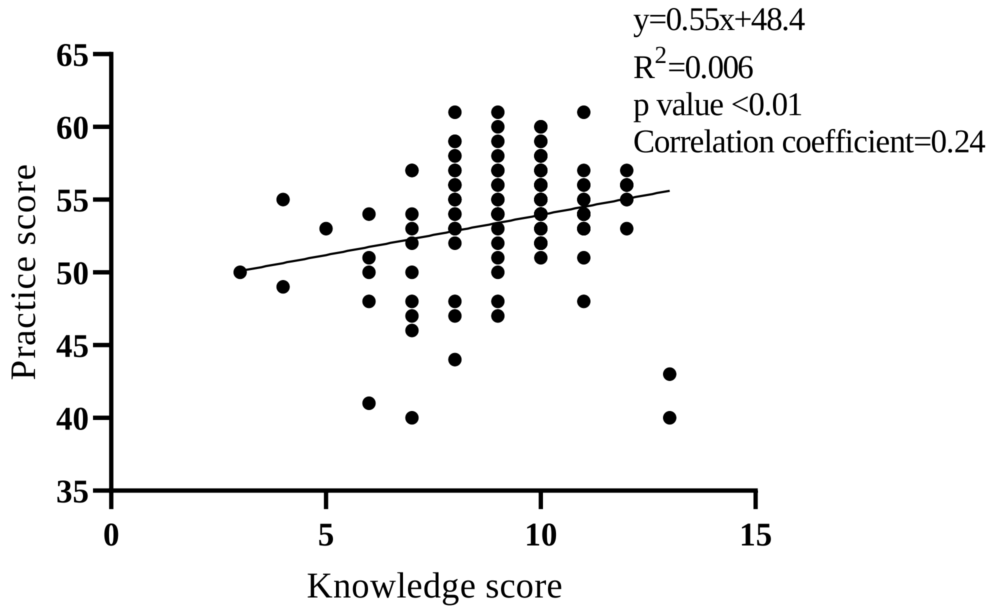


Figure 5.3 Scatter plot of knowledge and practice score

5.2.1.1 Knowledge and practice scores of pesticide use by type of farming

The category of knowledge score of pesticide use is shown in Table 5.1. Overall, 53.3% of the farmers were categorised as having a good knowledge of pesticide use; 59.0% of rice farmers had good knowledge compared to 46.3% of vegetable/fruit farmers (p=0.12).

Table 5.1: Category of knowledge score of pesticide use

Category of Knowledge score, n (%)	Total (n=150)	Type of farming		
		Rice (n=83)	Vegetable/Fruit(n=67)	P value [c]
Good [a]	80 (53.3)	49 (59.0)	31 (46.3)	0.12
Poor [b]	70 (46.7)	34 (41.0)	36 (53.7)	

[a] Knowledge score above median, [b] Knowledge score below median, [c] P value by Chi-Square test

Of the 13 questions that assessed knowledge of pesticide use, two questions were answered differently by rice and vegetable/fruit farmers (Figure 5.4). More rice farmers knew about carbamate being a rat poison than vegetable/fruit farmers (p=0.02). Meanwhile, more vegetable/fruit farmers knew about the importance of wearing gloves during spraying than rice farmers (p=0.02).

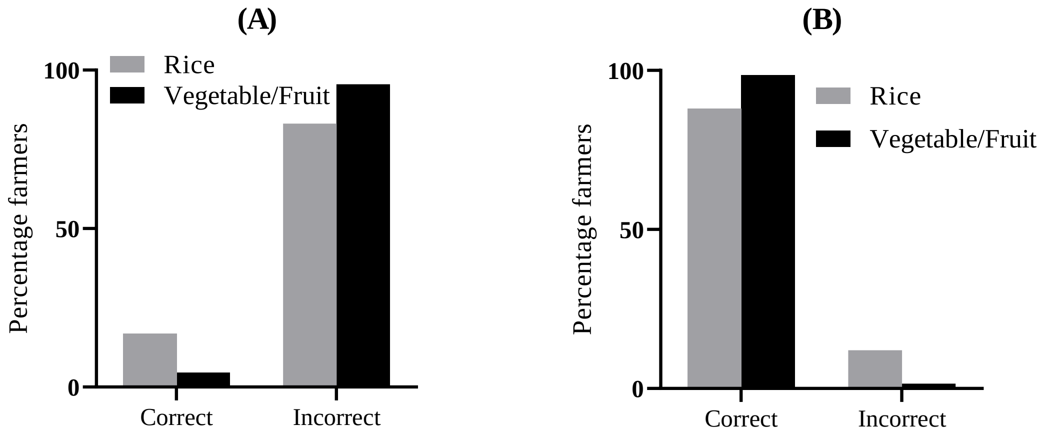


Figure 5.4: Two questions that were answered differently by rice and vegetable/fruit farmers (A) Carbamate is a rat poison, and (B) Gloves are important to wear during spraying

Category of practice score of pesticide use is shown in Table 5.2. Overall, 42.7% of the farmers were categorised as having a good practice score with 53.7% of vegetable/fruit farmers having a good score compared with only 33.7% of rice farmers ($p<0.01$).

Table 5.2: Category of practice score of pesticide use

Category of Practice score	Total (n=150)	Type of farming		
		Rice (n=83)	Vegetable/Fruit (n=67)	P value [c]
Good, n (%) [a]	64 (42.7)	28 (33.7)	36 (53.7)	<0.01
Poor, n (%) [b]	86 (57.3)	55 (66.3)	31 (46.3)	

[a] Practice score above median, [b] Practice score below median, [c] P value by Chi-Square test

Of the 16 questions that assessed practice of pesticide use, four questions were answered differently by rice and vegetable/fruit farmers (Figure 5.5). Before spraying, 65.9% of the vegetable/fruit farmers never mixed pesticides with other materials compared to 28.9% of the rice farmers ($p<0.01$). During spraying, 49.4% of rice farmers never sprayed upwind compared to 28.4% of vegetable/fruit farmers ($p=0.01$). After the spraying, 65.1% of the rice farmers always stored pesticides in a cabinet compared to 29.9% of the vegetable/fruit farmers ($p<0.01$). Nearly all of the rice farmers washed hands and face immediately compared to 92.5% of vegetable/fruit farmers ($p=0.03$).

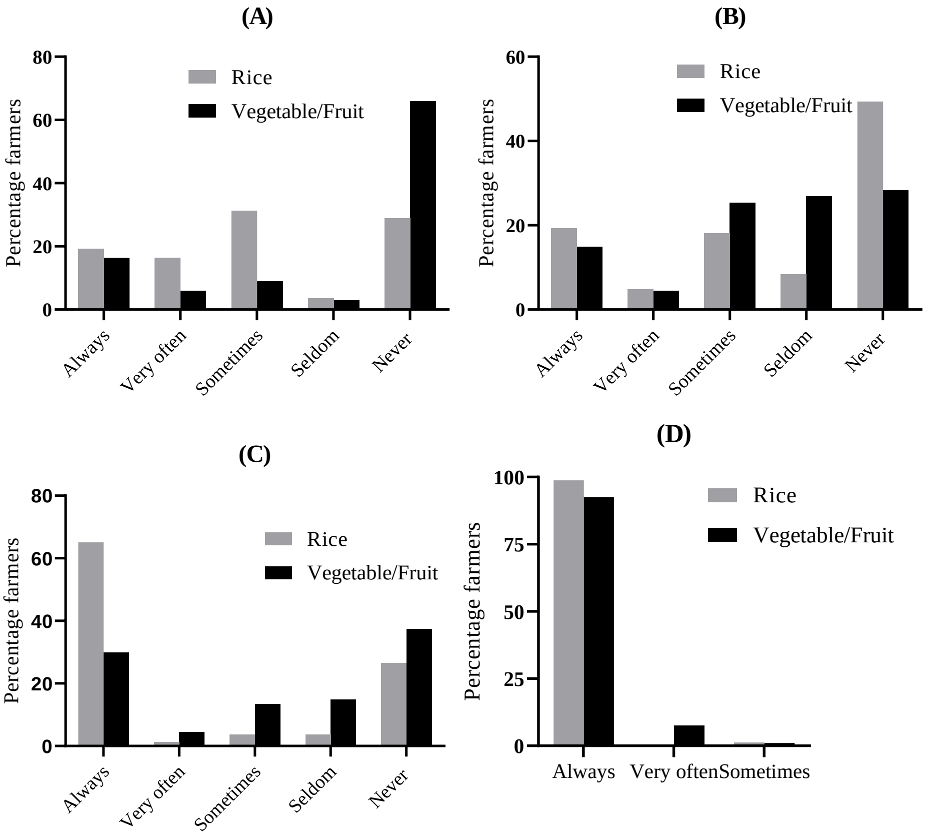


Figure 5.5: Four questions that were answered differently by rice and vegetable/fruit farmers (A) Mixed pesticides with other materials, (B) Spraying upwind, (C) Store pesticides in cabinets, and (D) Wash hands and face immediately

5.2.1.2 Association between knowledge and practice scores of pesticide use and demographic factors

Table 5.3 shows the association between knowledge and practice scores of pesticide use and demographic factors among the farmers. There were no association between knowledge and practice scores of pesticide use and demographic factors among the farmers.

5.2.1.3 Associations between knowledge and practice scores of pesticide use and occupational histories and working practices during previous spraying sessions

Table 5.4 describes the associations between knowledge and practice scores of pesticide use and occupational histories and working practices of the farmers during previous spraying sessions. The farmers who had good knowledge scores, sprayed for shorter durations each day and per week than those who had poor knowledge scores ($p<0.01$ and $p=0.03$ respectively). The use of backpacker sprayers was higher among those farmers who had poor knowledge scores ($p<0.01$). The farmers who had good knowledge scores were more likely to use PPE than poor practice scores ($P<0.01$). The farmers who had poor knowledge scores were more likely to become bystander farmers and re-enter into sprayed field than those with good knowledge scores ($p<0.01$, respectively).

The farm size of farmers who had a good practice score was lower than farmers with poor practice scores ($p=0.03$). The farmers who sprayed less than one day or less per week had good practice score compared to those who has poor practice score ($p<0.01$). The use of backpacker sprayers was higher among those farmers who had good practice scores compared with those had poor practice scores ($p=0.02$). The farmers who had poor practice scores were more likely to re-enter into sprayed field than good practice scores ($p<0.05$). The nature of incident while using pesticides among farmers who had poor practice scores was leakage whereas those farmers who had good practice scores the nature of the incident was either leakage or spillage ($p=0.02$).

5.2.1.4 Associations between knowledge and practice scores of pesticide use and post work hygienic behaviour of farmers during previous spraying sessions

Table 5.5 describes the associations between knowledge and practice scores of pesticide use and the washing and showering behaviour of the farmers. There was no association between washing and showering behaviour and knowledge and practice of pesticide use.

Table 5.6 shows associations between repairing and cleaning equipment after spraying among the farmers and knowledge and practice scores of pesticide use. The farmers who had poor knowledge score repaired equipment more than farmers who had good knowledge scores ($p<0.01$). The farmers who had poor knowledge score always wash equipment ($p<0.01$) and more likely clean equipment at home ($p<0.01$) more than farmers who had poor knowledge score.

Table 5.3: Associations between demographic factors with knowledge and practice scores of pesticide use

Variable	Knowledge score			Practice score		
	Good (n=80)	Poor (n=70)	P value	Good (n=64)	Poor (n=86)	P value
Age, yrs			0.87 [a]			0.51 [a]
Mean±SD	47.5 ±15.9	47.6 ±15.9		48.8± 15.0	46.7± 16.5	
Min-Max	17-81	18-72		18-75	17-81	
BMI, n (%)			0.09 [b]			0.31 [b]
Under weight	1 (1.3)	9 (12.9)		6 (9.4)	4 (4.7)	
Normal weight	53 (66.3)	43 (61.4)		36 (56.3)	60 (69.8)	
Overweight	22 (27.4)	15 (21.4)		18 (28.0)	19 (22.0)	
Obesity	4 (5.0)	3 (4.3)		4 (6.3)	3 (3.5)	
Marital status, n (%)			0.27 [c]			0.73 [c]
Single	11 (13.8)	15 (21.4)		9 (14.1)	17 (19.7)	
Married/Widowed	69 (86.2)	55 (78.6)		55 (86.9)	69 (80.3)	
Educational level, n (%)			0.74 [c]			0.58 [b]
Never been to school	5 (6.3)	5 (7.1)		3 (4.7)	7 (8.1)	
Primary education	20 (25.0)	21 (30.0)		15 (23.4)	26 (30.3)	
Secondary education	47 (58.7)	40 (57.1)		41 (64.1)	46 (53.5)	
Tertiary education	8 (10.0)	4 (5.8)		5 (7.8)	7 (8.1)	
Income per month, n (%)			0.08 [c]			0.18 [c]
Low income	40 (50.0)	47 (67.1)		33 (51.6)	54 (62.8)	
Middle income	40 (50.0	23 (32.9)		31 (48.4)	32 (37.2)	
Smoking status, n (%)			0.15 [c]			0.06 [c]
Current/ex-smokers	60 (75.0)	45 (64.3)		50 (78.1)	55 (64.0)	
Non-smokers	20 (25.0)	35 (35.7)		14 (21.9)	31 (36.0)	

[a] P value by Independent T test, [b] P value by Fisher Exact test, [c] P value by Chi Square test

Table 5.4: Associations between occupational histories with knowledge and practice scores of pesticide use

Variable	Knowledge score			Practice score		
	Good (n=80)	Poor (n=70)	P value	Good (n=64)	Poor (n=86)	P value
Age start working			0.07 [a]			0.77 [a]
Median (Q1-Q3)	18.0 (14.0-20.0)	18.0 (15.8-20.0)		18.0 (15.3-20.0)	18.0 (15.0-20.0)	
Duration work as farmers			0.76 [a]			0.53 [a]
Median (Q1-Q3)	18 (6.3-37.8)	20 (6.0-36.3)		20.0 (7.8-36.0)	16.5 (6.0-3.7)	
Farm size			0.97 [a]			0.03 [a]
Median (Q1-Q3)	3.8 (2.0-10.0)	4.0 (2.0-10.0)		3.0 (1.0-8.8)	5.0 (2.0-13.5)	
Farm owner, n (%)			1.00 [b]			0.51 [b]
Yes	79 (98.8)	69 (98.6)		64 (100)	84 (97.7)	
No	1 (1.2)	1 (1.4)		0 (0.0)	2 (2.3)	
Task involved, n (%)						
Diluting concentrate	78 (97.5)	69 (98.6)	0.64 [b]	62 (98.4)	85 (97.7)	1.00 [b]
Preparation	79 (98.8)	69 (98.6)	1.00 [b]	63 (100)	85 (97.7)	0.51 [b]
Spraying per day			<0.01 [a]			0.36 [a]
Median (Q1-Q3)	1.0 (1.0-2.0)	2.0 (1.0-2.3)		2.0 (1.0-2.0)	2.0 (1.0-2.0)	
Days sprayed per week, n (%)			0.03 [b]			<0.01 [b]
1 day or less	16 (20.0)	22 (31.4)		25 (39.1)	13 (15.1)	
2-3 days	52 (65.0)	31 (44.3)		27 (42.2)	56 (65.1)	
4-5 days	10 (12.5)	9 (12.9)		8 (12.5)	11 (12.8)	
6-7 days	2 (2.5)	8 (11.4)		4 (6.3)	6 (7.0)	
Mixing pesticide, n (%)			0.60 [b]			0.39 [b]
<50% of time	0 (0.0)	5 (7.1)		1 (1.6)	4 (4.7)	
>50% of time	80 (100)	65 (92.9)		63 (98.4)	82 (95.3)	
Application method, n (%)			<0.01 [b]			0.02 [b]
Backpack sprayer	50 (62.5)	56 (80.0)		49 (76.6)	57 (66.3)	
Power sprayer	7 (8.8)	13 (18.6)		11 (17.2)	9 (10.5)	

Blower	23 (28.7)	1 (1.4)		4 (6.3)	20 (23.3)	
PPE use, n (%)			<0.01 [c]			0.36 [c]
Yes	72 (90.0)	42 (60.0)		51 (79.7)	63 (73.3)	
No	8 (10.0)	28 (40.0)		13 (20.3)	23 (26.7)	
Bystander farmers, n (%)			<0.01 [c]			0.79 [c]
Yes	8 (10.0)	24 (34.3)		13 (20.3)	19 (22.1)	
No	72 (90.0)	46 (65.7)		51 (79.7)	67 (77.9)	
Re-entry into sprayed field, n (%)			<0.01 [c]			<0.05 [c]
Yes	11 (13.8)	27 (38.6)		11 (17.2)	27 (31.4)	
No	69 (86.3)	43 (61.4)		53 (82.8)	59 (68.6)	
Incident while using pesticide, n (%)			0.94 [c]			0.09 [c]
Yes	19 (23.8)	17 (24.3)		11 (17.2)	25 (29.1)	
No	61 (76.2)	53 (75.7)		53 (82.8)	61 (70.9)	
Nature of incident, n (%); n (36)			0.14 [b]			0.02 [b]
Leakage	16 (84.2)	10 (58.8)		15 (60.0)	11 (100)	
Spillage	3 (15.8)	7 (41.2)		10 (40.0)	0 (0.0)	

[a] P value by Mann-Whitney U test, [b] P value by Fisher Exact test, [c] P value by Chi Square test

The majority of farmers who had good practice score repaired sprayed equipment more than farmers who had poor practice score ($p<0.01$). The farmers who had poor practice score were more likely to sometimes ($p=0.01$) wash the equipment after pesticide use ($p=0.02$) compared to farmers who had good practice score.

5.2.1.5 Associations between knowledge and practice scores of pesticide use and pesticide use in first 24 hours of current spraying week

Table 5.7 describes the associations between knowledge and practice scores of pesticide use and pesticide use of the farmers in first 24 hours of current spraying week. The majority of farmers who had good practice score use a single type of pesticide ($p<0.01$) and also did not use fungicides ($p<0.01$) compared with farmers who had poor practice score. There were no significant associations between knowledge of pesticide use and pesticide use.

5.2.1.6 Associations between knowledge and practice scores of pesticide use and AHS and EFS pesticide exposure intensity scores and DREAM scores

Table 5.8 describes the associations between knowledge and practice scores of pesticide use and AHS and EFS pesticide exposure intensity scores and DREAM scores. The farmers who had poor practice score had higher EFS median scores compared to those who had a good score ($p=0.06$).

5.2.1.7 Logistic regression analysis of knowledge and practice scores of pesticide use

Table 5.9 shows the predictors of poor knowledge score of pesticide use among the farmers. In a multiple logistic regression model, adjusting for age, the OR (95% CI) for poor knowledge was 5.18 (1.45, 18.50) for not using PPE, 7.68 (1.86, 31.68) for those with were bystander farmers and 1.79 (1.23, 2.52) for repaired equipment after pesticide use.

Table 5.10 shows the predictors of poor practice of pesticide use among the farmers. Binary logistic regression analyses adjusting for age and farm size showed that farmers who re-entered into a sprayed field and had wash equipment had 63.0% (OR=0.37; 95%CI: 0.15, 0.95) and 64.0% lower (OR=0.34; 95%CI: 0.14, 0.91) risk of poor practice score of pesticide use, respectively. The farmers who had sprayed 1 day or less also showed 76.0% lower (OR=0.24; 95%CI: 0.09, 0.60) of having poor practice score.

5.2.2 Associations between PPE use and demographic factors, working practices and pesticide use

In the previous chapter, the percentage of PPE use among farmers has been discussed. In summary, 76.0% of the farmers used PPE and there was no difference in the proportion of rice or vegetable/fruit farmers using PPE (Section 4.2.1.5). In this section, associations between PPE use and demographic factors, working practices and pesticide use will be discussed.

5.2.2.1 Associations between PPE use and demographic factors

Table 5.11 shows the associations between PPE use and demographic factors among the farmers. The farmers who did not use PPE were underweight compared to those who used PPE (p=0.01).10.5% of the farmers who used PPE completed tertiary education compared to none of the farmers who reported not using PPE (p=0.02).

5.2.2.2 Associations between PPE use and occupational histories and working practices during previous spraying sessions

Table 5.12 shows the associations between PPE use and occupational histories and working practices of the farmers during previous spraying sessions. Farmers who did not use PPE tended to spray for longer than those farmers who used PPE (p=0.01). Farmers who used backpack sprayers tended not to wear any PPE (p=0.02). Among farmers who had bystander exposure (p=0.04) and also re-entered sprayed areas, the majority of them did not wore PPE (p<0.01).

5.2.2.3 Associations between PPE use and post-spraying hygienic behaviour of farmers during previous spraying sessions

Table 5.13 shows the associations between PPE use and washing and showering behaviour of farmers. None of farmers who used PPE changed into clean clothes the

Table 5.5: Associations between the washing and showering behaviour with knowledge and practice scores of pesticide use

Variable	Knowledge score			Practice score		
	Good (n=80)	Poor (n=70)	P value [a]	Good (n=64)	Poor (n=86)	P value [a]
Change into clean clothes, n (%)			0.32			0.15
Right away	79 (98.8)	67 (95.7)		62 (96.9)	84 (97.7)	
Later at the end of the day	1 (1.2)	1 (1.4)		2 (3.1)	0 (0.0)	
Next day or later in the week	0 (0.0)	2 (2.9)		0 (0.0)	2 (2.3)	
Shower after spraying pesticide, n (%)			0.08			0.64
Right away	80 (100)	66 (94.3)		63 (98.4)	83 (96.5)	
Later at the end of the day	0 (0.0)	4 (5.7)		1 (1.6)	3 (3.5)	
Wash hand/arm after spraying pesticide, n (%)			0.47			1.00
Right away	80 (100)	69 (98.6)		64 (100)	85 (98.9)	
Later at the end of the day	0 (0.0)	1 (1.4)		0 (0.0)	1 (1.2)	

[a] P value by Fisher Exact test

Table 5.6: Associations between repaired and cleaning equipment after spraying with knowledge and practice scores of pesticide use

Variable	Knowledge score			Practice score		
	Good (n=80)	Poor (n=70)	P value	Good (n=64)	Poor (n=86)	P value
Repair spraying or mixing equipment, n (%)			<0.01 [a]			<0.01 [a]
Yes	41 (51.2)	59 (84.3)		55 (85.9)	45 (52.3)	
No	39 (49.8)	11 (15.7)		9 (14.1)	41 (47.7)	
Wash equipment after pesticide use, n (%)			0.08 [b]			0.02 [a]
Yes	68 (85.0)	51 (72.9)		45 (70.3)	74 (86.0)	
No	12 (15.0)	19 (27.1)		19 (29.7)	12 (14.0)	
Frequency clean spraying equipment (n=119), n (%)			<0.01 [b]			0.01 [b]
Always	9 (13.3)	19 (37.3)		16 (35.6)	12 (16.2)	
Most of the times	7 (10.3)	12 (23.5)		10 (22.2)	9 (12.2)	
Half of the times	2 (2.9)	3 (5.9)		2 (4.4)	3 (4.1)	
Sometimes	50 (73.5)	17 (33.3)		17 (37.8)	50 (67.6)	
Place clean spraying equipment (n=119), n (%)			<0.01 [a]			0.83 [a]
Farm	58 (85.3)	31 (60.8)		33 (73.3)	56 (75.7)	
Home	10 (14.7)	20 (39.2)		12 (26.7)	18 (24.3)	
Activity when clean spraying equipment (n=119), n (%)			0.08 [b]			0.24 [b]
Hose down the sprayer	0 (0.0)	3 (5.9)		2 (4.4)	1 (1.4)	
Clean nozzle	0 (0.0)	3 (5.9)		0 (0.0)	3 (4.1)	
Rinse tank	68 (100)	45 (88.2)		43 (95.6)	70 (94.6)	
Material used to clean the equipment (n=119), n (%)			0.41 [b]			0.15 [b]
Sand only	0 (0.0)	1(2.0)		1 (2.2)	0 (0.0)	
Water only	60 (88.2)	37 (72.5)		35 (77.8)	67 (90.5)	
Water and soap	8 (11.8)	12 (23.5)		8 (17.8)	7 (9.5)	
Cleaning agent	0 (0.0)	1 (2.0)		1 (2.2)	0 (0.0)	

[a] P value by Chi-Square test, [b] P value by Fisher Exact test

Table 5.7 Association between pesticide used in first 24 hours of current spraying week with knowledge and practice scores of pesticide use

Variable	Knowledge score			Practice score		
	Good (n=80)	Poor (n=70)	P value [a]	Good (n=64)	Poor (n=86)	P value [a]
Number of pesticide(s), n (%)			0.09			<0.01
Single pesticide	28 (35.0)	34 (48.6)		37 (57.8)	25 (29.1)	
More than one	52 (65.0)	36 (51.4)		27 (42.2)	61 (70.9)	
Type of pesticide, n (%)						
Insecticide	63 (78.8)	58 (82.9)	0.53	49 (76.6)	72 (83.7)	0.27
Herbicide	19 (23.8)	10 (14.3)	0.14	17 (26.6)	12 (14.0)	0.05
Fungicide	32 (40.0)	21 (30.0)	0.20	14 (21.9)	39 (45.3)	<0.01

[a] P value by Chi-Square test

Table 5.8: Associations between knowledge and practice scores of pesticide use and pesticide exposure algorithm and DREAM score

Variable	Knowledge score			Practice score		
	Good (n=80)	Poor (n=70)	P value [a]	Good (n=64)	Poor (n=86)	P value [a]
EFS score Median (Q1-Q3)	151.1 (101.1-220.8)	151.1 (108.9-251.9)	0.50	137.9 (69.9-245.4)	163.3 (108.9-233.0)	0.06
AHS score Median (Q1-Q3)	2.4 (2.3-2.5)	2.4 (2.4-2.9)	0.24	2.4 (2.4-2.4)	2.4 (2.3-2.5)	0.90
DREAM scores, Median (Q1-Q3)	84.9 (41.3-125.4)	63.0 (38.4-121.1)	0.40	63.2 (40.4-128.9)	87.8 (39.2-115.5)	0.49

[a] P value by Mann-Whitney U test

next day compared to 5.6% of farmers who did not use PPE (p=0.03). All of the farmers who used PPE showered right away after spraying pesticides compared to 88.9% of farmers who not used PPE (p<0.01).

Table 5.9: Predictors for poor knowledge score of pesticide use among the farmers

Variable	Simple logistic regression		Multiple logistic regression [a]	
	Crude OR (95% CI)	P value	Adjusted OR (95% CI) [b]	P value
Longer duration of spraying	2.32 (1.47, 3.65)	<0.01	1.99 (1.00, 3.96)	0.05
Had sprayed 1 day or less	0.23 (0.15, 1.16)	0.11	0.28 (0.10, 1.97)	0.32
Used power sprayer/blower	0.42 (0.20, 0.87)	0.02	0.93 (0.21, 4.06)	0.92
Not used PPE	6.00 (2.51, 14.37)	<0.01	5.18(1.45, 18.50)	0.01
Bystander farmers	4.70 (1.95, 11.34)	<0.01	7.68 (1.86,31.68)	<0.01
Had re-entry into sprayed field	2.25 (1.32, 3.76)	<0.01	1.65 (0.46, 5.93)	0.44
Repaired equipment after pesticide use	1.80 (1.15, 2.75)	<0.01	1.79 (1.23, 2.52)	<0.01
Always/most of the time clean spraying equipment	5.04 (2.28, 11.14)	<0.01	1.58 (0.52, 4.86)	0.42
Clean equipment in the farm	0.34 (0.17, 0.67)	<0.01	0.36 (0.12, 1.05)	0.06

[a] Forward and backward Multiple Logistic Regression model were applied and backward was used for final model, multicolinearity and interaction term were checked and not found, Hosmer-Lemeshow test (p=0.25) was applied to check the model fit
[b] Adjusted with age - Adjusted OR=1.02 (95% CI=0.98, 1.05)

Table 5.10: Predictors for poor practice score of pesticide use among the farmers

Variable	Simple logistic regression		Multiple logistic regression [a]	
	Crude OR (95% CI)	P value	Adjusted OR (95% CI) [b]	P value
Use power sprayer/blower	1.22 (0.59, 2.50)	0.59	0.55 (0.20, 1.52)	0.25
Rice farmers	2.15 (1.11, 4.16)	0.02	0.69 (0.22, 2.20)	0.54
Had sprayed 1 day or less	0.23 (0.10, 0.50)	0.01	0.24 (0.09, 0.60)	0.01
Had re-entry into sprayed field	0.37 (0.21, 0.80)	0.01	0.37 (0.15, 0.95)	0.04
Had repaired equipment	2.61 (1.19, 5.13)	0.02	2.22 (0.77, 6.38)	0.14
Had wash equipment after pesticide use	0.26 (0.11, 0.60)	0.01	0.36 (0.14, 0.91)	0.03
Had used more than one pesticide	1.57 (0.90, 3.39)	0.10	1.05 (0.45, 2.49)	0.91
Had used fungicide	1.03 (1.01, 1.12)	0.03	1.01 (0.95, 1.16)	0.27

[a] Forward and backward Multiple Logistic Regression model were applied and backward was used for final model, multicolinearity and interaction term were checked and not found, Hosmer-Lemeshow test (p=0.86) was applied to check the model fit
[b] Adjusted with age- Adjusted OR=0.99 (95% CI=0.98, 1.02) and farm size- Adjusted OR=1.03 (95% CI=0.96, 1.10)

Table 5.11: Association between PPE use and demographic factors

Variable	PPE use		
	Yes (n=114)	No (n=36)	P value
Age, yrs			0.52 [a]
Mean±SD	48.1±15.4	46 ±17.2	
Min-Max	17-81	18-77	
BMI, n (%)			0.01 [b]
Under weight	4 (3.5)	6 (16.7)	
Normal weight	71 (62.3)	25 (69.4)	
Overweight	33 (28.9)	4 (11.1)	
Obesity	6 (5.3)	1 (2.8)	
Marital status, n (%)			0.23 [b]
Single	16 (14.0)	10 (27.8)	
Married	95 (83.3)	26 (72.2)	
Widowed/Divorced	3 (2.7)	0 (0.0)	
Educational level, n (%)			0.02 [b]
Never been to school	9 (7.9)	1 (2.8)	
Primary education	25 (21.9)	16 (44.4)	
Secondary education	68 (59.6)	19 (52.8)	
Tertiary education	12 (10.6)	0 (0.0)	
Income per month, n (%)			0.49 [b]
Low income	63 (55.2)	24 (66.7)	
Middle income	51 (44.8)	12 (33.3)	
Smoking status, n (%)			0.62 [c]
Current/ex-smokers	81 (71.1)	24 (66.7)	
Non smokers	33 (28.9)	12 (33.3)	

[a] P value by Independent T-test, [a] P value by Fisher Exact test, [c] P value by Chi Square test

Table 5.12 Associations between PPE use and occupational histories and working practices during previous spraying sessions

Variable	PPE use		
	Yes (n=114)	No (n=36)	P value
Age start working, yrs			0.52 [a]
Median (Q1-Q3)	18 (15.0-20.0)	17 (15.0-20.0)	
Duration work as farmers, yrs			0.18 [a]
Median (Q1-Q3)	20 (6.0-37.0)	10 (6.5-10.0)	
Farm size, acre			0.56 [a]
Median (Q1-Q3)	4.0 (2.0-4.0)	4.0 (2.0-4.0)	
Farm owner, n (%)			1.00 [b]
Yes	112 (98.2)	36 (100)	
No	2 (1.8)	0 (0.0)	
Task involved, n (%)			
Diluting concentrate	112 (98.2)	35 (97.2)	0.56 [b]
Preparation	113 (99.1)	35 (97.2)	0.42 [b]
Spraying	114 (100)	36 (100)	
Spraying per day, hour			0.01 [a]
Median (Q1-Q3)	1.8 (1.0-2.0)	2.0 (1.0-2.8)	
Days sprayed per week, n (%)			0.70 [b]
1 day or less	31 (27.2)	7 (19.4)	
2-3 days	21 (58.3)	29 (43.3)	

4-5 days 6-7 days	13 (11.4) 8 (7.0)	6 (16.7) 2 (5.6)	
Mixing pesticide, n (%) <50% of time >50% of time	 2 (1.8) 112 (98.2)	 3 (8.3) 33 (91.7)	0.09 [b]
Application methods, n (%) Backpack sprayer Power sprayer Blower	 74 (64.9) 17 (14.9) 23 (20.2)	 32 (88.9) 3 (8.3) 1 (2.8)	0.02 [b]
Bystander farmers, n (%) Yes No	 20 (17.5) 94 (82.5)	 12 (33.3) 24 (66.7)	0.04 [c]
Re-enter into pesticide sprayed field, n (%) Yes No	 20 (17.5) 94 (82.5)	 18 (50.0) 18 (50.0)	<0.01 [c]
Incident while using pesticide, n (%) Yes No	 26 (22.8) 88 (77.2)	 10 (27.8) 26 (72.2)	0.54 [c]
Nature of incident (n=36), n (%) Leakage Spillage	 19 (73.1) 7 (26.9)	 7 (70.0) 3 (30.0)	1.00 [b]

[a] P value by Mann- Whitney U test, [b] P value by Fisher Exact test, [c] P value by Chi-Square test

Table 5.13: Associations between PPE use and washing and showering behaviour of farmers

Variable	PPE use		
	Yes (n=114)	No (n=36)	P value [a]
Change into clean clothes, n (%) Right away Later at the end of the day Next day or later in the week	 113 (99.1) 1 (0.9) 0 (0.0)	 33 (91.7) 1 (2.8) 2 (5.5)	0.03
Shower after spraying pesticide, n (%) Right away Later at the end of the day	 114 (100) 0 (0.0)	 32 (88.9) 4 (11.1)	<0.01
Wash hands/arms after spraying pesticide, n (%) Right away Later at the end of the day	 114 (100) 0 (0.0)	 35 (97.2) 1 (2.8)	0.24

[a] P value by Fisher Exact test

Table 5.14 shows the association between PPE use and repairing and cleaning equipment after spraying among the farmers. 33.3% farmers who did not use PPE always cleaned spraying equipment compared to only 20.2% farmers who used PPE ($p<0.01$).

5.2.2.4 Associations between PPE use and body contacts with pesticide during previous spraying sessions

Table 5.15 shows the associations between PPE use and body contacts with pesticide during previous spraying sessions. There was no significant association between PPE use and which part of the body was in contact with pesticides.

Table 5.14: Associations between PPE use and repairing and cleaning equipment after spraying among the farmers

Variable	PPE use		
	Yes (n=114)	No (n=36)	P value
Repair spraying or mixing equipment, n (%)			0.42 [a]
Yes	74 (64.9)	26 (72.2)	
No	40 (35.1)	10 (27.8)	
Clean equipment after pesticide use, n (%)			0.50 [a]
Yes	89 (78.1)	30 (83.3)	
No	25 (21.9)	6 (16.7)	
Frequency clean spraying equipment (n=119), n (%)			< 0.01 [b]
Always	18 (20.3)	10 (33.3)	
Most of the times	10 (11.2)	9 (30.0)	
Half of the times	0 (0.0)	5 (16.7)	
Sometimes	61 (68.5)	16 (20.0)	
Place clean spraying equipment (n=119), n (%)			0.49 [a]
Farm	68 (76.4)	21 (70.0)	
Home	21 (23.6)	9 (30.0)	
Activity when clean spraying equipment (n=119), n (%)			0.23 [b]
Hose down the sprayer	1 (1.1)	2 (6.7)	
Clean nozzle	2 (2.1)	1 (3.3)	
Rinse tank	86 (96.6)	27 (90.0)	
Material used to clean the equipment (n=119), n (%)			0.14 [b]
Sand only	1 (1.1)	0 (0.0)	
Water only	79 (88.8)	23 (76.7)	
Water and soap	9 (10.1)	6 (20.0)	
Cleaning agent	0 (0.0)	1 (3.3)	

[a] P value by Chi-Square test, [b] P value by Fisher Exact test

Table 5.15 Associations between PPE use and body contacts with pesticide during previous spraying sessions

Variable	PPE use		
	Yes (n=114)	No (n=36)	P value
Part of body in contact with pesticide, n (%)			
Head	41 (36.0)	9 (25.0)	0.23 [a]
Upper arms	1 (0.9)	0 (0.0)	1.00 [b]
Fore arms	25 (21.9)	12 (33.3)	0.17 [a]
Hands	90 (78.9)	27 (75.0)	0.62 [a]
Front of torso	9 (7.9)	2 (5.6)	1.00 [b]
Back of torso	22 (19.3)	4 (11.1)	0.32 [b]
Upper legs	9 (7.9)	1 (2.8)	0.45 [b]
Lower legs	32 (28.1)	7 (19.4)	0.30 [a]
Feet	41 (36.0)	13 (36.1)	0.99 [a]

[a] P value by Chi-Square test, [b] P value by Fisher Exact test

5.2.2.5 Associations between PPE use and pesticides used on first 24 hours of current spraying week

Table 5.16 shows the association between PPE use and pesticide use of the farmers during the first 24 hours of current spraying week. There were no significant associations between PPE use and pesticide usage among the farmers.

Table 5.16: Associations between PPE use and pesticide use on first day of current spraying week

Variable	PPE use		
	Yes (n=114)	No (n=36)	P value [a]
Number of pesticide(s), n (%)			0.96
Single pesticide	47 (41.2)	15 (41.7)	
More than one	67 (58.8)	21 (58.3)	
Type of pesticide, n (%)			
Insecticide	92 (80.7)	29 (80.6)	0.99
Herbicide	24 (21.1)	5 (13.9)	0.34
Fungicide	42 (36.8)	11 (30.6)	0.49

[a] P value by Chi-Square test

5.2.2.6 Logistic regression analysis of determinants for PPE use

Table 5.17 show the predictors of PPE use among the farmers. Binary logistic regression adjusted analyses included the following potential confounders: age, BMI, and education level. Farmers who used power sprayer/blower had nearly a 4 fold increase (OR=3.77; 95% CI: 1.11, 12.74) of using PPE. Though, farmers who had re-enter into the field being sprayed had a 64.0% reduction (OR=0.36; 95% CI: 0.14, 0.92) of using PPE.

Table 5.17: Predictors for PPE use among the farmers

Variable	Simple logistic regression		Multiple logistic regression [a]	
	Crude OR (95% CI)	P value	Adjusted OR (95% CI) [b]	P value
Duration of spraying in hour/day	0.63 (0.41, 0.97)	0.03	0.79 (0.46, 1.34)	0.38
Used of power sprayer/blower	4.32 (1.43, 13.10)	0.01	3.77 (1.11, 12.74)	0.03
Being a bystander during exposure	0.60 (0.38, 0.95)	0.03	1.74 (0.61, 4.59)	0.26
Had re-enter into field being sprayed	0.21 (0.09, 0.48)	<0.01	0.36 (0.14, 0.92)	0.03

[a] Forward LR Multiple Logistic Regression model was applied, multicolinearity and interaction term were checked and not found, Hosmer-Lemeshow test (p=0.21) was applied to check the model fit
[b] Adjusted with age -Adjusted OR=1.01, (95% CI=0.98, 1.03), BMI -Adjusted OR=0.39 (95% CI=0.13, 1.15) and education level - Adjusted OR=0.56 (95% CI=0.24, 1.30)

5.3 DISCUSSION

In this study, the knowledge and practice of pesticide use among 150 farmers in two areas in Kelantan state were assessed. There is a scarcity of information about knowledge and practice of pesticide use as well as the lack of scientific data on PPE use among this population in Malaysia. Hence, the results from this chapter provide insight and highlights gaps regarding the knowledge and practice of pesticide use among the farmers and its associated factors. Besides, the determinants of PPE use also have been discussed.

5.3.1 Statement of principal findings

The vegetable/fruit farmers had a higher practice score of pesticide use compared to rice farmers ($p<0.01$). However, this did not observe for knowledge score of pesticide use. A poor knowledge score of pesticide use was associated with not using PPE, repairing equipment after pesticide use and being a bystander farmer. In addition, a poor practice score of pesticide use was associated with duration of spraying more than one day, did not re-entry into a sprayed field and did not wash equipment. PPE use was associated with increase used of power sprayer/blower and did not re-enter into field being sprayed.

5.3.2 Possible explanation of findings

A few studies have examined the association between knowledge and practice of pesticide use and associated factors (140,197,217,219,220) Table 5.18 shows the association between knowledge and practice of pesticide use and associated factors in previous studies. Many previous studies showed that knowledge of pesticide use was associated with age, education level, farm size, farmer’s experience and training and pesticide used (140,217,219,220). However, these associations were not observed in this study. This study showed that repairing equipment after pesticide use, being a bystander farmer and not use of PPE was associated with poor knowledge. This is similar to results from previous studies conducted in Palestine and Malaysia (140,217).

Table 5.18 Association between knowledge and practice of pesticide use and demographics and work factors in various studies

Variable	Knowledge of pesticide use	Practice of pesticide use
Age	Older age was associated with good knowledge [a] (217)	NPD [b]
Educational level	Higher education was associated with increased level of knowledge (140,219,220)	NPD [b]
Duration of spraying	Lesser spraying duration was associated with good knowledge [a] (140,217)	Lesser spraying duration was associated with better practice (217)
Size of farm	The larger the farm size , the better the knowledge (219)	NPD [b]
Working experience as a farmer	Less experienced as a farmer was associated with good knowledge [a] (140)	NPD [b]
Pesticide use	Use of pesticides for more than 10 years was associated with good knowledge [a] (140) Decrease years of pesticide use, was associated with better knowledge (220)	NPD [b]
PPE use	Use of PPE was associated with good knowledge [a] (197)	NPD [b]
Training	The farmers who had training had more good knowledge [a] (219,220)	NPD [b]

[a] The knowledge score about mean and [b] No Published Data

This study found that the farmers who had poor practice sprayed more than one day, did not re-entry into a sprayed field and did not wash equipment. However, none of the previous studies observed these associations (197,217,219,220).

The findings from this study showed several interesting associations between PPE use and pesticide exposure. Significant relationships between PPE use and the use power sprayer/blower and did not re-entered into spraying farm were observed. Based on the results in this study, the method of the application had an influence on the decision to use PPE. One plausible reason might be because of the complex and heavier the sprayer, the more likely the farmer was to use PPE. This present study found a significant association between re-entry to the farm and PPE use, where the majority of farmers who did not re-enter the farming area use PPE. This is an interesting finding and need further study to investigate this association.

The education level was not significantly associated with PPE use. This is not in line with a study done in Ghana, which reported that the level of education is related to the decision to use PPE (221). A study was done in Greece also supported these findings as it indicated that the level of education was a determinant for PPE use

(222). The education of farmers will determine the level of knowledge about the adverse effects of pesticides and the importance of safety measures, which motivate them to use PPE during pesticide handling. However, this is not observed in this study probably because of the working culture not properly used PPE among this farming area irrespective to the education background. Although no statistical significance was found in the differences in PPE use and age, the results showed that those who use PPE were more likely to be among older farmers. This result implies that older farmers are more concerned regarding health-protective behaviour compared to younger farmers. In general, this finding appears consistent with other studies in the USA (223).

An incident while using pesticides did not show any significant association with PPE use. This finding is inconstant with a previous study conducted in Colombia, where farmers who had experienced incidents in the past more likely to use PPE (224). This suggesting that the farmers learn from the previous incident and they need to be extra cautious to prevent the exposure. In this study, farm size does not influence on wearing of PPE. However, previous studies concluded farm size had a significant association with the decision to wear PPE, where it is likely that the larger farm size takes a longer time to complete the task (221). A significantly higher proportion of farmers who used PPE reported changing into clean clothing and showering right away after exposure. This demonstrates the farmers' follow the recommendation on safety measures during pesticide application (221).

The result of this study showed that the more than half of the farmers had good knowledge score but poor practice score of pesticide use. Many studies have been conducted in developing countries to assess knowledge and practice of pesticide use. In a study conducted among palm oil workers in Malaysia, the workers had a low level of knowledge, when the total score less than 80% but were excellent in practice, when the practice score above 80% (218). In another study conducted in the Cameroon among smallholder farmers, they were found to have inadequate knowledge but the practice was not assessed (225). Another study conducted in Iran among farmers showed similar results where most of the farmers did not have proper knowledge (226). However, the comparison findings from previous studies need to be done carefully, mainly because they used different questions and analysis related to knowledge and practice.

Very few farmers knew about carbamate. This lack of knowledge might be due to difficulty in understanding the technical term in the questionnaire. However, rice farmers knew more than vegetable/fruit farmers. During the first day of current spraying week in this study, more rice farmers used carbamate compared to vegetable/rice farmers. Hence, they were familiar with carbamate and this might be the possible reason why rice farmers know more than vegetable/rice farmers. More vegetable/fruit farmers answered correctly that gloves are important to wear during spraying. This could be because in this study more vegetable/fruit farmers wore gloves more than rice farmers even though not statistically significant and became their practice while spraying pesticides.

More than half of the vegetable/farmers never mixed pesticides with the other materials compared to only 30% of rice farmers. This practice of mixed pesticides with other materials is considered cost effective and saves them time. However, this can potentially cause problems such as poor performance due to antagonism of action and also improper mixing order (227).

More than half of the rice farmers never sprayed upwind compared to around 30% for vegetable/fruit farmers. This is consider a good practice because applying the pesticide upwind had a significantly increase risk of adverse health effects (228). Figure 5.6 shows the rice farmer spraying upwind.

Safety is the key element in pesticide storage. More than half of the rice farmers always stores pesticides in cabinets compared to around 30% for vegetable/fruit farmers. This is considered the safest approach. However, in order to comply with regulation, the cabinet need to be lock and should be properly identified with a sign. The cabinet also need to be access to those who properly trained in the use pesticide (229).

Figure 5.6 Example of poor practices while using pesticide where the rice farmer spraying upwind

More than 90% of the farmers were always practising change clothes, wash hands and shower immediately. This suggests that the farmers have good practice in hygiene and sanitation and in line with Malaysia Good Agricultural Practice (My GAP). However, better facilities and infrastructure such as changing rooms need to be improved.

5.3.3 Strengths and weaknesses of the study

One of the strengths of this study, to my knowledge, this current study might be the first one to investigate the knowledge and practice of pesticide use among farmers in Kelantan. In addition, the questionnaire that have been used was comprehensive and addressed almost all pesticide use items which had been validated in previous study (230).

The limitation must be considered when interpreting the results. First, this study was conducted in one area in Malaysia. Therefore, it might not be representative and may be difficult to generalise the results of this study to other populations in

Malaysia as maybe the results different in other difference study population. The information obtained from this study was self-reported by the farmers, which is prone to potential recall bias.

5.3.4 Potential implications and future study

Data generated by this study suggests that training is needed among this population. Pesticide use training for farmers is likely to be an important intervention that can reduce exposure to pesticides. This intervention needs to be done to educate the farmers on the correct way of dealing with personal hygiene and sanitation practices before, during and after application of pesticide and also of the importance in using PPE correctly. In this training, some effort should be given to targeting farmers who repair spraying equipment. Hopefully, by educating them, new habits will be installed, which will improve their health.

Questionnaire knowledge and practice provides useful inputs to policy makers about decision making for farmer's training. The findings of the study will assist the policy makers to reduce the effect of pesticide exposure. My GAP standard with the objective of improving the safety and quality of agricultural produce and safety was implementing in Malaysia in 2002. However, because of costs, many small holder farmers were not interested in joining this program (231). Hence, at the local government level, either the government itself or NGOs should provide free health literacy programs for those small-scale farmers who have not been able to join My GAP. This will provide an opportunity for the farmers to gain knowledge on best pesticide practice.

5.4 CONCLUSION

This research provides interesting findings about knowledge and practice related to pesticide use among the farmers. It is important to underline that, not use PPE, bystander farmers and repaired spraying equipment were associated with increase poor knowledge scores of pesticide use and increase poor practice scores of pesticide use was associated with long duration of working, did not re-entry into sprayed field, and not washing equipment. It is important to note that the pesticide exposure such as used of power sprayer/blower and did not re-enter into field was associated with PPE use. These findings provide an opportunity for further training and research.

CHAPTER 6: SELF-REPORTED ACUTE HEALTH SYMPTOMS DURING A WEEK FOLLOWING SPRAYING

6.1 INTRODUCTION

In addition to chronic health problems, recent epidemiological studies have provided evidence of the impact of pesticide exposure especially to OP pesticides, producing both mild and severe acute symptoms such as irritation of the nose, throat, eyes or skin, headache, dizziness and others in agricultural workers (127). Several studies have been conducted looking at acute health symptoms among workers in Malaysia and these have similarly reported symptoms such as diarrhoea, vomiting, dizziness, and numbness (44,62,132,133,165). All the studies used a cross-sectional study design and not a longitudinal or follow up study after exposure. They also used questionnaires to evaluate the symptoms. For the exposures, the studies used questionnaires (44,62,132,133,165), personal air sampling (62), buccal swab (133) or DREAM questionnaire (62). However, the association between symptoms and occupational exposure to pesticide in these studies were not well established and remain unclear.

This study has shown that the farmers were exposed to pesticides during pesticide use by the detection of pesticide metabolites in their urine (Chapter 4). This chapter will focus on acute ill health effects following pesticide exposure in order to address the limitations of previous studies conducted in Malaysia. The findings of acute health effects will provide implications for strategies to reduce the risk of health effects.

6.1.1 Aims and objectives

The aims for the work described in this chapter were to investigate the nature and determinants of acute health symptoms reported following pesticide spraying

The specific objectives were to

a) Determine the nature and prevalence of self- reported acute health symptoms occurring 48 hours during a spraying week

b) Examine the association between self-reported acute health symptoms occurring 48 hours of spraying and demographics, working practices and pesticide exposure during first day of current spraying week

6.2 RESULTS

The study population in this chapter was the same as that of Chapter 4 and consisted of 150 farmers.

6.2.1 Activity during spraying week

Figure 6.1 shows the tasks done by the farmers during a week when they sprayed. On day 1, all farmers sprayed pesticide but the percentage spraying on subsequent days was lower (28% on day 2, 22.7% on day 3, 14.7% on day 4, 12.7% on day 5 and 10.7% on day 6). On day 7, 14% of farmers sprayed. Between 2% to 5.3% and 5.3% to 12% of farmers were bystanders when a field was being sprayed and worked in a sprayed field, respectively. On day 6, rice farmers sprayed more than vegetable/fruit farmers (p=0.03). On day 2, more rice farmers were bystanders and worked in sprayed fields than vegetable/fruit farmers (p=0.07). On all other days, no significant association was observed between the type of farming and activities carried out (Data not shown).

6.2.2 Self-reported ill-health during the spraying week

On the day before spraying, none of the farmers reported that they felt ill whereas 32.7% of farmers reported on at least one occasion a health symptom occurring within 48hours after spraying in the spraying week (Table 6.1). Symptoms were more common among rice farmers compared to vegetable/fruit farmers (p=0.04). Among those farmers who reported symptoms, the majority of them had two or more symptoms with rice farmers more likely to have two or more symptoms than vegetable/fruit farmers (p=0.03).

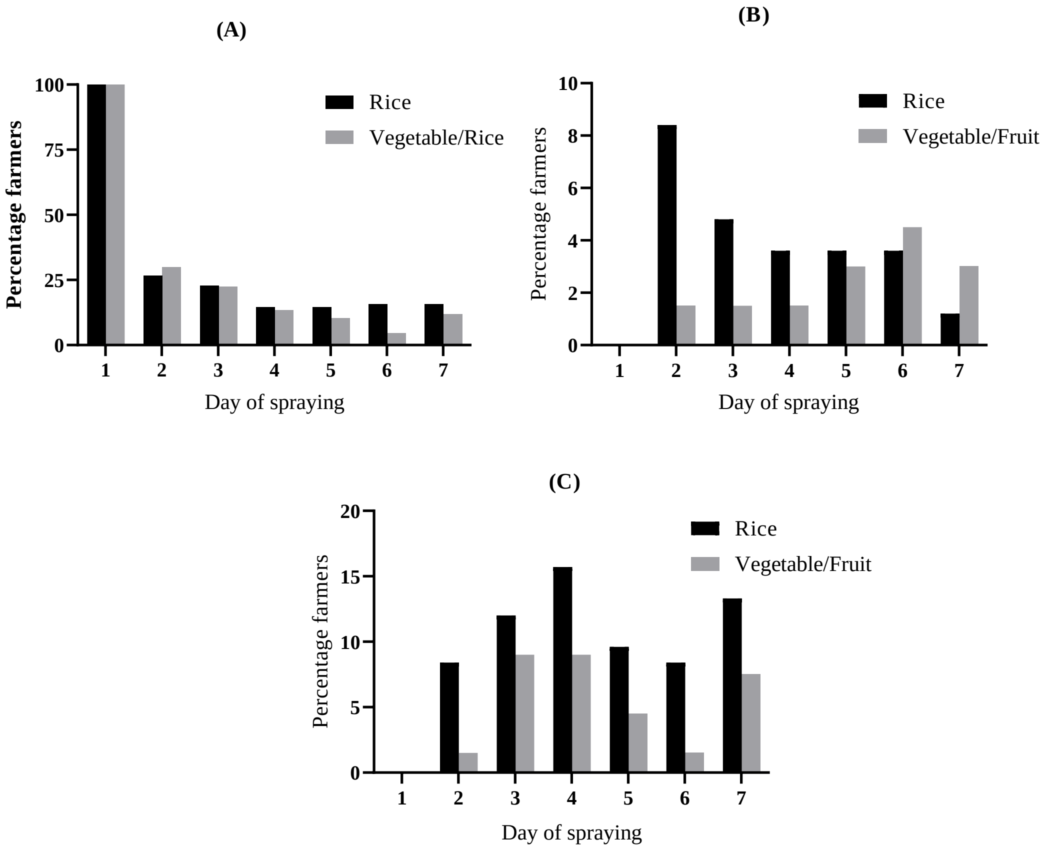


Figure 6.1: Task done by the farmers during a week following spraying
(A) Spraying, (B) Bystander at field being sprayed, (C) Working in a field that
(B) had been sprayed
*Scale of Y-axis is difference between graphs

Table 6.1: Percentage of symptoms occurring within 48 hours of spraying reported by the farmers

Variable	Total, n (150)	Type of farming		P value
		Rice (n=83)	Vegetable/Fruit (n=67)	
Symptom, n (%)				0.04 [a]
Yes	49 (32.7)	33 (39.8)	16 (24.0)	
No	101 (67.3)	50 (60.2)	51 (76.0)	
Number of symptom, n (%)				0.03 [b]
0	101 (67.3)	50 (60.2)	51 (76.0)	
1	10 (6.7)	5 (6.0)	5 (7.5)	
2	22 (14.7)	17 (20.5)	5 (7.5)	
3	9 (6.0)	8 (9.7)	1 (1.5)	
4	3 (3.0)	1 (1.2)	2 (3.0)	
≥ 5 [c]	5 (3.3)	2 (2.4)	3 (4.5)	

[a] P value by Chi-Square test, [b] P value by Fisher Exact test, [c] Of the 2 rice farmers, 1 had 10 symptoms and 1 had 19 symptoms and of the 3 vegetable/fruit farmers, 1 had 8 symptoms, 1 had 10 symptoms and 1 had 20 symptoms

Figure 6.2 shows how the symptoms varied over the seven days following the first day of spraying, with symptoms peaking on day 1 of the spraying week and gradually reducing over the week. On day 1, 30% of the farmers experienced symptoms and 17.3% of the farmers experienced symptoms on day 2, followed by 7.3% on day 3, 10% on day 4 and 8% from day 5 till day 7. On day 1, 71.1% of rice farmers reported symptoms but only 28.9% of vegetable/fruit farmers, a difference that was statistically significant (p=0.01). There were no other significant differences between type of farming and reported symptoms on day 2 till day 7 (Data not shown).

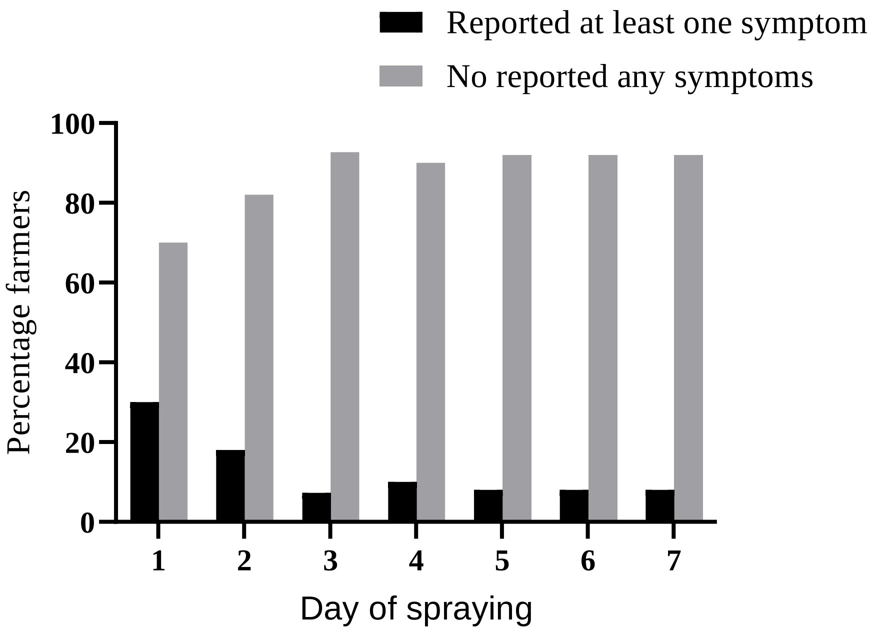


Figure 6.2: Frequency of farmers who reported and not reported a symptom on any specific day over seven days following on 48 hours after spraying

Figure 6.3 shows the percentage of farmers with one, two and three of more symptoms. The percentage of farmers who reported one symptom was higher on day 2, whereas it was higher on day 1 for those who reported either two or three or more symptoms.

The number of farmers with symptoms varied with day after spraying (Figure 7.4). On days 1, 3 and 5, among the farmers who reported symptoms, the highest percentage of farmers experienced two symptoms. On days 2 and 6, the highest percentage of farmers experienced only one symptom. On days 4 and 7, the highest percentage of farmers experienced three or more symptoms.

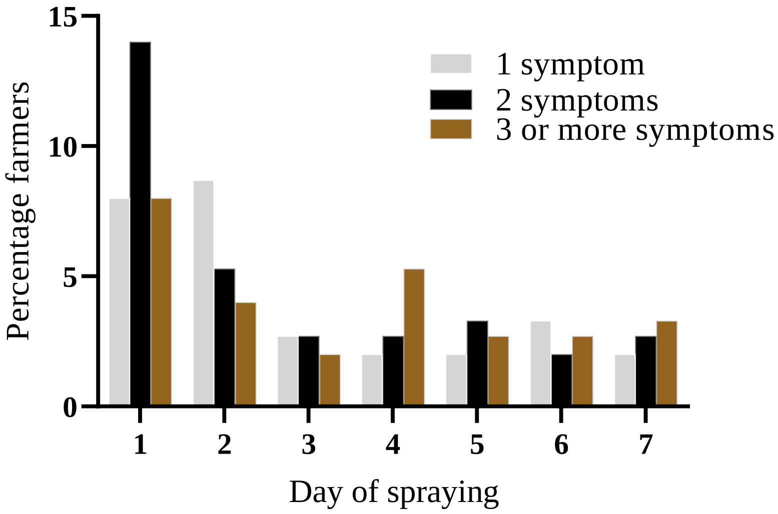


Figure 6.3: Percentage of farmers who reported one, two and three or more symptoms

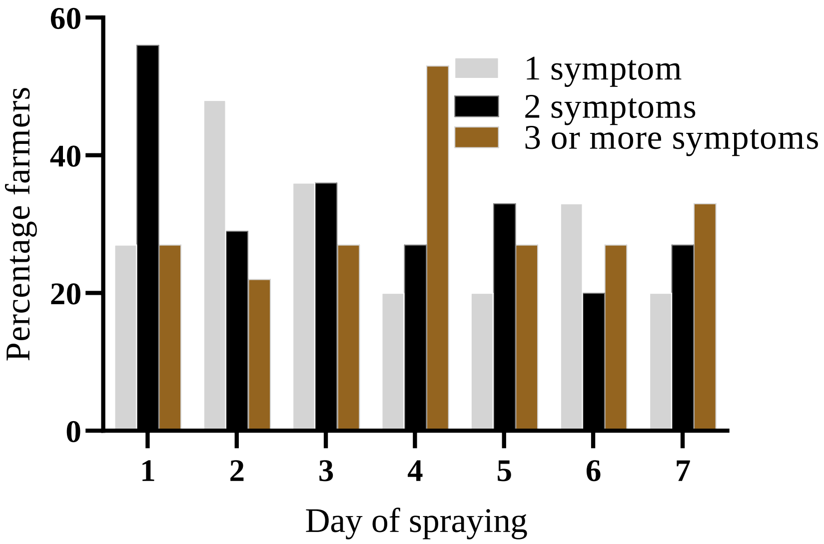


Figure 6.4: Percentage of farmers reporting one, two and more than two symptoms by day
*The percentage is based on farmers who had symptoms

The frequency of individual self-reported health symptoms up to seven days after the first day of spraying is shown in Figure 6.5. Following pesticide spraying, the most common symptom on day 1 was feeling unusually tired which accounted for 16% of reports but there was no significant difference between type of farming (p=0.44). Other common symptoms were feeling sweaty, shivery and feverish (13.3%) and having a headache (13%) and there was again no significant difference between type of farming (p=0.16) and (p=0.06), respectively. The prevalence of all other symptoms was below 10.0%. On day 2, headache was the principal symptom experienced by 10.7% of farmers and there was no difference between type of farming (p=0.25). All other symptoms were reported by less than 10% of farmers and the frequency of all symptoms was below 10% on day 3 onwards.

6.2.3 Variation of pyrexial and respiratory factors occurring within 48 hours of spraying over the week following spraying

18.7% and 2.7% of the farmers were identified as having either a pyrexial or respiratory factor occurring within 48 hours of spraying, respectively (Table 6.2). No significant association was found between these symptom complexes and the type of farming.

Table 6.2 Percentage of farmers categorised as having pyrexial or respiratory factor occurring within 48 hours of spraying

Factor	Type of farming		
	Rice (n=83)	Vegetable/Fruit (n=67)	P value
Pyrexia, n (%) [a]	15 (18.1)	13 (19.4)	0.84 [c]
Respiratory, n (%) [b]	3 (3.6)	1 (1.5)	0.63 [d]

[a] Consisted of four symptoms including feeling generally ill, unusually tired, sweaty, shivery, feverish, hot or cold and headache, [b] Consisted of five symptoms including runny, stuffy, blocked or irritated nose, cough, shortness of breath, wheeze and eye irritation, [c] P value by Chi-Square test, [d] P value by Fisher Exact test

The percentage of farmers with the pyrexial factor was highest on day 1 which accounted for 14.7% of farmers and decreased on day 2 (6.7%) and remained relatively unchanged from day 3 in a range between 4% to 5.3%.

On day 1 till day 4, only two farmers were identified as having respiratory factor and this was reduced to one farmer on day 5 and day 6. On day 7, none of the farmers were identified as having the respiratory factor (Figure 6.6).

Figure 6.7 shows how the percentage of farmers experiencing the pyrexial factor occurring 48 hours after spraying varied with the type of farming. The pyrexial factor was more common among rice farmers than vegetable/fruit farmers but there were no significant difference between type of farming and pyrexial factor (Data not shown).

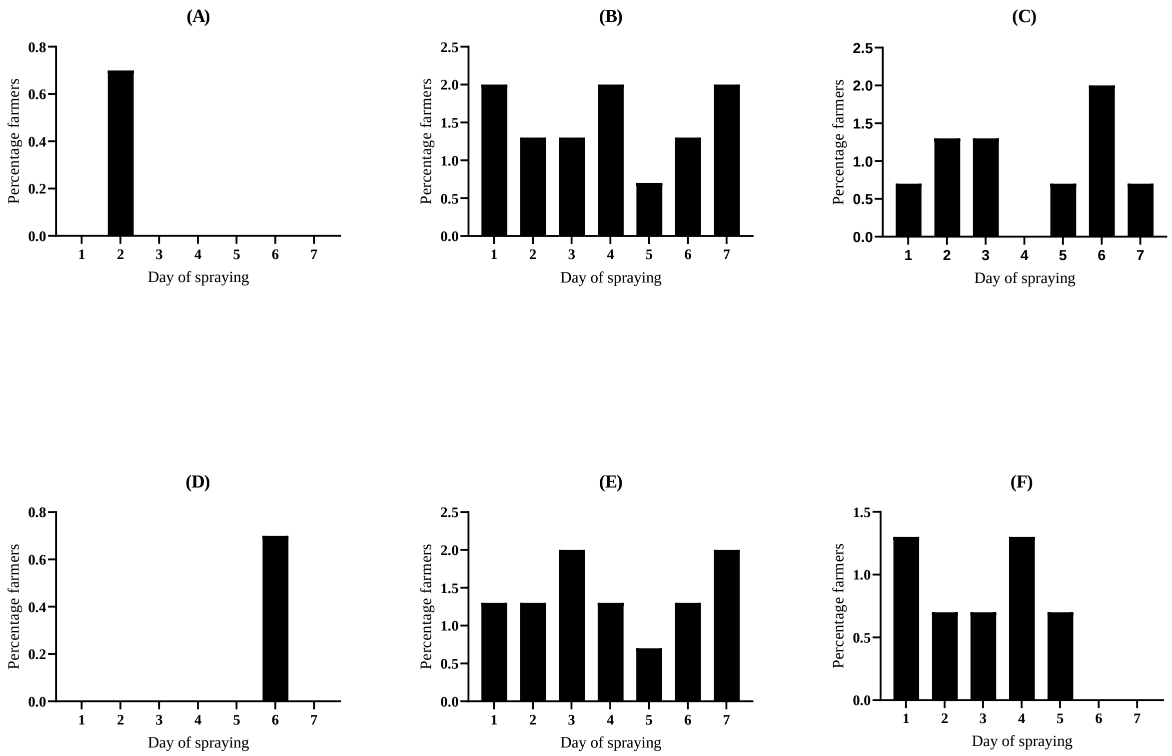


Figure 6.5 Frequency of specific diary symptoms and symptom complexes by day after sprayed
(A) Abdominal cramp, (B) Anxiety, (C) Cough, (D) Diarrhoea, (E) Dry mouth, (F) Eye irritation
*Scale of Y axis is difference between graphs

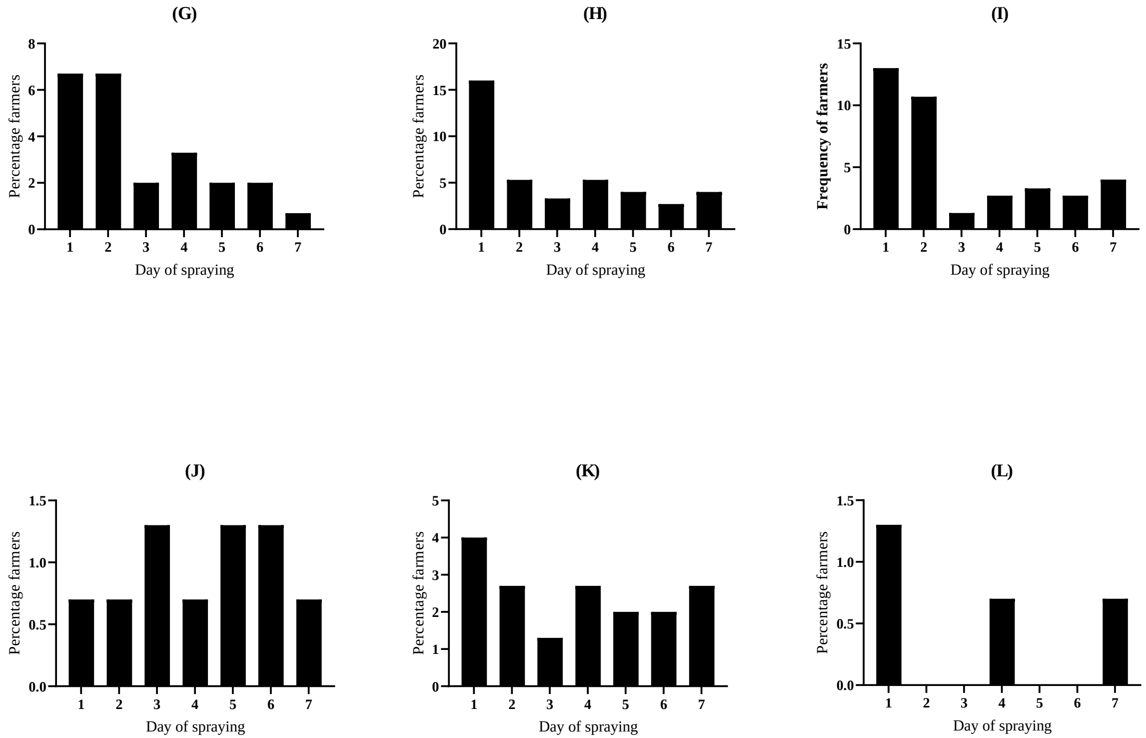


Figure 6.5 (Cont.) Frequency of specific diary symptoms and symptom complexes by day after sprayed
(G) Feeling generally ill, (H) Feeling unusually tired, (I) Headache, (J) Hoarse voice, (K) Increased thirst, (L) Nausea and vomiting
*Scale of Y axis is difference between graphs

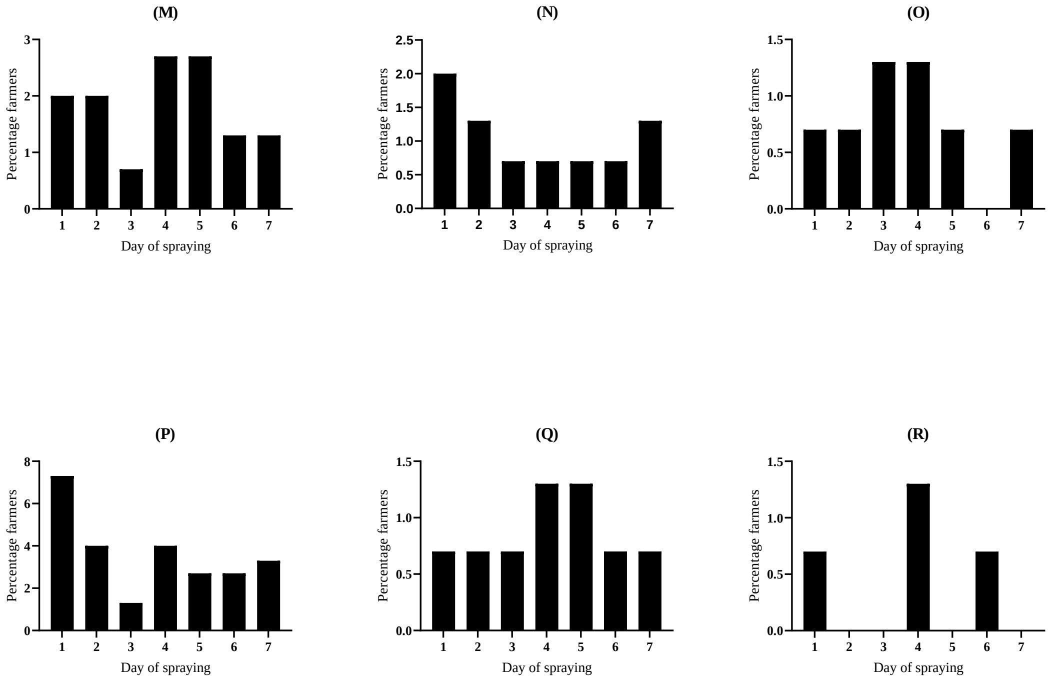


Figure 6.5 (Cont.) Frequency of specific diary symptoms and symptom complexes by day after sprayed
(M) Palpitation, (N) Passing less urine, (0) Poor appetite, (P) Pain in muscle or joint, (Q) Runny nose, blocked or irritated nose, (R) Shortness of breath
*Scale of Y axis is difference between graphs

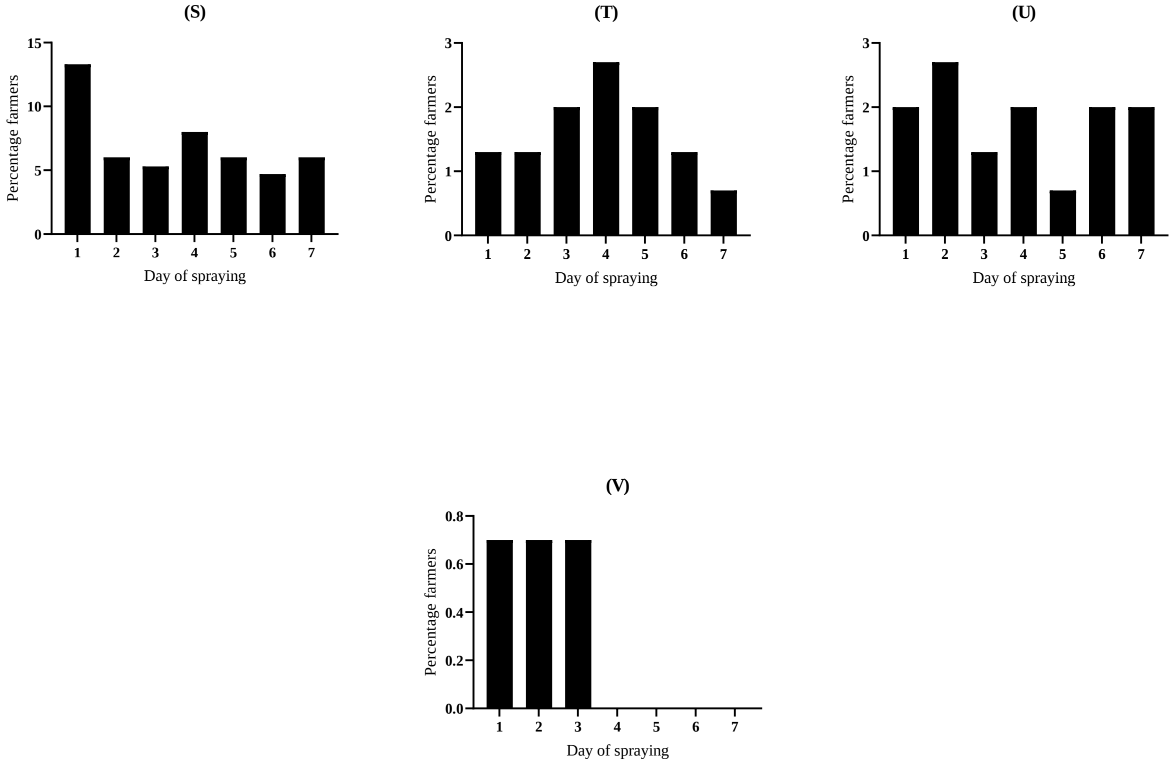


Figure 6.5 (Cont.) Frequency of specific diary symptoms and symptom complexes by day after sprayed
(S) Sweaty, shivery and feverish, (T) Sore throat, (U) Tremor, (V) Wheeze
*Scale of Y axis is difference between graphs

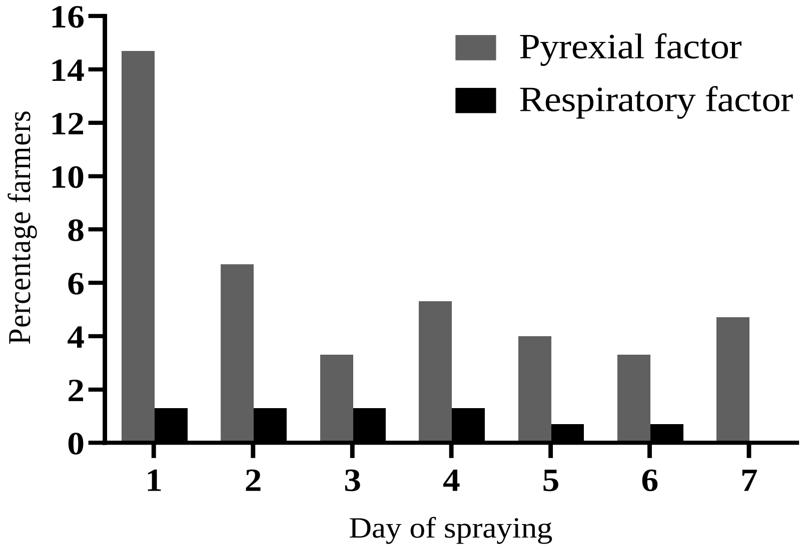


Figure 6.6: The frequency of identified symptom factors occurring 48 hours after spraying

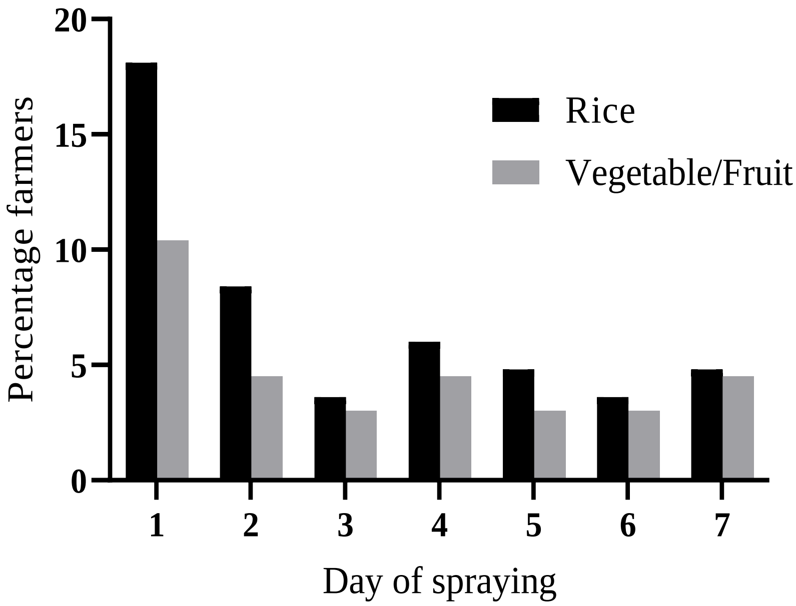


Figure 6.7: Frequency of the pyrexial factor among rice and vegetable/fruit farmers occurring 48 hours after spraying

6.2.4 Determinants of pyrexial factor risk occurring 48 hours after spraying over the week

Only the pyrexial factor will be examined because of the low number of farmers identified as having the respiratory factor.

6.2.4.1 Associations between the pyrexial factor occurring 48 hours after spraying and demographic factors

Table 6.3 shows the associations between the pyrexial factor occurring 48 hours after spraying and demographic factors among the farmers. The farmers who experienced the pyrexial factor were younger (p=0.01), single (p=0.03) and from low income families (p=0.03).

Table 6.3: Associations between the pyrexial factor occurring 48 hours after spraying and demographic factors

Variable	Pyrexial factor		
	Yes (n=28)	No (n=122)	P value
Age, yrs			0.01 [a]
Mean±SD	39.8±17.7	49.4 ±14.9	
Min-Max	21-77	17-81	
BMI, n (%)			0.33 [b]
Under weight	4 (14.3)	6 (4.9)	
Normal weight	16 (57.1)	80 (65.6)	
Overweight	7 (25.0)	30 (24.6)	
Obesity	1 (3.6)	6 (4.9)	
Marital status, n (%)			0.03 [b]
Single	10 (35.7)	16 (13.1)	
Married	18 (64.3)	103 (84.4)	
Widowed/ Divorced	0 (0.0)	3 (2.5)	
Educational level, n (%)			0.38 [b]
Never been to school	0 (0.0)	10 (8.2)	
Primary education	8 (28.6)	33 (27.0)	
Secondary education	9 (32.1)	68 (55.7)	
Tertiary education	11 (39.3)	11 (9.0)	
Income per month, n (%)			0.03 [c]
Low income	22 (78.6)	65 (53.3)	
Middle income	6 (21.4)	57 (46.7)	
Smoking status, n (%)			0.78 [c]
Current smokers/ex-smokers	19 (67.9)	86 (70.5)	
Non-smokers	9 (32.1)	36 (29.5)	

[a] P value by Independent T-test, [b] P value by Fisher Exact test ,[c] P value by Chi-Square test

6.2.4.2 Associations between the pyrexial factor occurring 48 hours after spraying and working practices during the first 24 hours of spraying

Table 6.4 shows the associations between the pyrexial factor occurring 48 hours after spraying and working practices during the first 24 hours of spraying. 53.6% of farmers who experienced the pyrexial factor washed equipment after pesticide use compared to 32.8 % of farmers who did not experience the pyrexial factor (p=0.04). The farmers who experienced pyrexial factor also wore face shields more (p<0.01) and chemically resistant boots (p=0.02) less that those farmers who did not experience the pyrexial factor. 71.4% of farmers who experienced the pyrexial factor had chest, back and abdomen (p=0.04) and legs (p=0.02) contact with pesticide during application compared to around 50% of farmers who did not experience the pyrexial factor.

Table 6.4: Associations between the pyrexial factor occurring 48 hours after spraying and working practices during the first 24 hours of spraying

Variable	Total (n=150)	Pyrexial factor		
		Yes (n=28)	No (n=122)	P value
Duration of spraying, n (%)				0.21 [a]
Less than one hour	120 (80.0)	20 (71.4)	100 (82.0)	
More than one hour	30 (20.0)	8 (28.6)	22 (18.0)	
Amount of pesticide, n (%)				0.58 [a]
Less than 30 ml	93 (62.0)	16 (57.1)	77 (63.1)	
More than 30 ml	57 (38.0)	12 (42.9)	45 (36.9)	
Application methods, n (%)				0.13 [b]
Backpack sprayer	116 (77.3)	23 (82.1)	93 (76.2)	
Power sprayer	13 (8.7)	4 (14.3)	9 (7.4)	
Blower	21 (14.0)	1 (3.6)	20 (16.4)	
Clothes wore during application, n (%)				
Hat	105 (70.0)	18 (64.3)	87 (71.3)	0.47 [a]
Goggles	6 (3.3)	1 (4.0)	5 (4.1)	1.00 [b]
Dusk mask	58 (38.7)	9 (32.1)	49 (40.2)	0.43 [a]
Face shields	27 (18.0)	12 (42.9)	15 (12.3)	<0.01 [a]
Gloves	30 (20.0)	4 (14.3)	26 (21.3)	0.40 [b]
Long sleeve shirt	106 (70.7)	19 (67.9)	87 (71.3)	0.72 [a]
Short sleeve shirt	44 (29.3)	9 (32.1)	35 (28.7)	0.72 [a]
Apron	3 (2.0)	1 (3.6)	2 (1.6)	0.51 [b]
Chemically resistant suit	1 (0.7)	0 (0.0)	1 (0.8)	1.00 [b]
Long trousers	138 (86.7)	25 (89.3)	113 (92.6)	0.56 [b]
Short trousers	12 (8.0)	3 (10.7)	9 (7.4)	0.70 [b]
Chemically resistant boots	126 (84.0)	19 (67.9)	107 (87.7)	0.02 [b]
Shoes	18 (12.0)	5 (17.9)	13 (10.7)	0.29 [b]
Body contact with pesticide during application, n (%)				
Head or face	60 (40.0)	12 (42.9)	48 (39.3)	0.73 [a]
Arms	115 (76.7)	23 (82.1)	92 (75.4)	0.45 [a]
Chest, back and abdomen	81 (54.0)	20 (71.4)	61 (50.0)	0.04 [a]
Legs	78 (52.0)	20 (71.4)	58 (47.5)	0.02 [a]
Feet	69 (46.0)	14 (50.0)	55 (45.1)	0.64 [a]
Wash equipment after pesticide use, n (%)				0.04 [a]
Yes	55 (36.7)	15 (53.6)	40 (32.8)	
No	95 (63.3)	13 (46.4)	82 (67.2)	
Repair spraying or mixing equipment, n (%)				0.20 [a]
Yes	44 (29.3)	11 (39.3)	33 (27.0)	
No	106 (70.7)	17 (60.7)	89 (73.0)	

[a] P value by Chi-Square test, [b] P value by Fisher Exact test

6.2.4.3 Association between the pyrexial factor occurring 48 hours after spraying and pesticides used during the first 24 hours of spraying

Table 6.5 shows the association between the pyrexial factor occurring 48 hours after spraying and pesticides used by the farmers during the first 24 hours of spraying. There was no significant association between pyrexia and pesticide use among the farmers. Out of 67 active ingredients, farmers with pyrexial symptoms used 14 active ingredients more than those farmers who did not have pyrexial symptoms. Out of 14 active ingredients, there was one significant association between the pyrexial factor and fentin acetate (p=0.01) where the farmers who had the pyrexial factor were more likely to use fentin acetate (Table 6.6).

Table 6.5: Associations between the pyrexial factors occurring 48 hours after spraying and pesticide used on first 24 hours of spraying

Variable	Pyrexial factor		
	Yes (n=28)	No (n=122)	P value
Number of pesticide(s), n (%)			0.15 [a]
Single pesticide	15 (53.6)	47 (38.5)	
More than one	13 (46.4)	75 (61.5)	
Type of pesticide, n (%)			
Insecticide	21 (75.0)	100 (82.0)	0.40 [a]
Herbicide	4 (14.3)	25 (20.5)	0.60 [b]
Fungicide	11 (39.3)	42 (34.4)	0.63 [a]

[a] P value by Chi-Square test, [b] P value by Fisher Exact test

6.2.4.4 Associations between the pyrexial factor occurring 48 hours after spraying and pesticide exposure intensity score, DREAM score and urine metabolite

Table 6.7 shows the associations between the pyrexial factor occurring 48 hours after spraying and pesticide exposure intensity score, DREAM score and urine metabolite. There was no significant association between pyrexial factor and pesticide exposure intensity score, DREAM scores and level of urinary metabolite.

6.2.4.5 Logistic regression analysis of potential risk factors for pyrexial factor

Table 6.8 shows the final model for predictors for pyrexial factor among the farmers. The farmers who wore face shields had nearly a 3-fold (OR 2.9; 95% CI: 1.01, 8.71) increased risk of having prexial factor than those who did not and the farmers who wore chemical resistant boots had a reduced risk of having pyrexial factor (OR 0.23; 95%CI: 0.08, 0.70).

6.3 DISCUSSION

6.3.1 Principal findings

This study demonstrates the presence of acute health symptoms reported by the farmers following pesticide use. The overall prevalence of symptoms was 31% and feeling unusually tired, feeling sweaty, shivery and feverish and having a headache were highest reported symptoms within 48 hours of the spraying event. The reported symptoms were more common among rice farmers than vegetable/fruit farmer and the majority of rice farmers experienced more than two symptoms. 18.7% of farmers had a pyrexia factor but few farmers a respiratory factor. The farmers who used fentin acetate were prone to get pyrexial factor. The risk of the pyrexial factor was increased in farmers who wore face shields and decreased among farmers who wore chemical resistant boots.

6.3.2 Possible explanations for findings

This study determined that rice farmers reported significantly more ill-health symptoms than vegetable/ fruit farmers. In a study conducted in Malaysia, shows that 41% of the rice farmers reported cough symptom, followed by wheezing (18.1%) and difficulty in breathing (16.9%) (44). Similarly, another study conducted in Nigeria among rice farmers reported that the most common symptoms were eye irritation which accounted for 66.7%, followed by dizziness (58.3%) and vomiting (56.8%) (232). This is possibly due to rice farmers in this study population having increased pesticide exposure due to poorer use of PPE, increased use of power sprayers and blowers, longer duration of spraying and increased farm size compared to vegetable/rice farmers. However, the self-reported ill-health may have resulted from factors, other than pesticide exposure, such as the hot climate or ergonomic problems from carrying heavy spraying equipment or are the result of existent health problems.

Table 6.6: Associations between pyrexia factors occurring 48 hours after spraying and pesticide used based on active ingredient during the first 24 hours of spraying

Type of chemical class	Active ingredient	Pyrexial factor, n (%)		
		Yes (n=28)	No (n =122)	P value
Acetamide	Pretilachlor	0 (0.0)	1 (0.8)	0.19 [a]
	Propanil	1 (3.6)	1 (0.8)	0.34 [a]
Acetamide/Benzoid	Pretilachor/Pyribenzoxim	0 (0.0)	1 (0.8)	0.19 [a]
Acylananine/Carbamate	Metalaxy/Mancozeb	0 (0.0)	1 (0.8)	0.19 [a]
Aryloxypyrimidine	Azoxystrobin	0 (0.0)	1 (0.8)	1.00 [a]
Aryloxypyrimidine/Triazole	Azoxystrobin/ Difenoconazole	1 (3.6)	7 (5.7)	1.00 [a]
Azole	Carbendazim	0 (0.0)	5 (4.1)	0.38 [a]
	Difenoconazole	0 (0.0)	2 (1.6)	1.00 [a]
	Epoxiconazole	0 (0.0)	1 (0.8)	1.00 [a]
	Tricyclazone	1 (3.6)	8 (6.6)	1.00 [a]
Benzoylurea	Flufenoxuron	0 (0.0)	4 (3.3)	1.00 [a]
	Lufenuron	0 (0.0)	2 (1.6)	1.00 [a]
Carbamate	Flubendiamide	5 (17.9)	14 (11.5)	0.36 [b]
	Mancozeb	0 (0.0)	9 (7.4)	0.21 [a]
	Pyraclostrobin	0 (0.0)	1 (0.8)	1.00 [a]
	Propamocard hydrochloride	0 (0.0)	1 (0.8)	1.00 [s]
	Propineb	2 (7.1)	8 (6.6)	1.00 [a]
Carbamate/Azole	Mancozeb/Carbendazim	1 (3.6)	2 (1.6)	0.46 [s]
Chloride	Paraquat Dichloride	1 (3.6)	10 (8.2)	0.69 [s]
Formetanate	Formetanate	0 (0.0)	1 (0.8)	1.00 [a]
Macrocyclic lactone	Abamectin	3 (10.7)	7 (5.7)	0.4 [a]
Malonate ester	Isoprothiolane	1 (3.6)	6 (4.9)	1.00 [a]
Natural	Bacillus Thuringiensis	0 (0.0)	3 (2.5)	1.00 [a]

Neonicotiniods	Imidacloprid Acetamiprid	3 (10.7) 0 (0.0)	6 (4.9) 1 (0.8)	0.37 [a] 1.00 [a]
Neonicotiniods/Pyrethroid	Imidacloprid/Beta-Cyfluthrin	0 (0.0)	1 (0.8)	1.00 [a]
Neonicotinoid/Diamine	Thiamethoxam/Chloraniliprole	0 (0.0)	6 (4.9)	0.6 [a]
Nereistoxin	Cartap hydrochloride	0 (0.0)	1 (0.8)	1.00 [a]
Nitrate	Fenoxaprop ethyl	0 (0.0)	2 (1.6)	1.00 [a]
Organochlorine	Chlorfluazuron Pyridaben	0 (0.0) 0 (0.0)	1 (0.8) 1 (0.8)	1.00 [a] 1.00 [a]
Organophosphate	Chlorpyrifos Dimethoate Fenthion Glyphosate isopropylamine Malathion	0 (0.0) 1 (3.6) 0 (0.0) 0 (0.0) 1 (3.6)	10 (8.2) 2 (1.6) 1 (0.8) 2 (1.6) 1 (0.8)	0.21 [a] 0.46 [a] 1.00 [a] 1.00 [a] 0.34 [a]
Organophosphate/Carbamate	Fenitrothion/Fenobucarb	1 (3.6)	1 (0.8)	0.34 [a]
Organophosphate/Pyrethroid	Chlorpyrifos/Cypermethrin	2 (7.1)	13 (10.7)	0.74 [a]
Organotin	Fentin acetate	5 (17.9)	1 (0.8)	0.01 [a]
Oxazolidinone/ Acetamide	Clomazone /Propanil	0 (0.0)	1 (0.8)	1.00 [a]
Phenoxy	2,4-Butyester 2,4-D-dimethylammonium 2,4-D-Iso-butyl ester MCPA Dimethylammonium MCPA Potassium	0 (0.0) 1 (3.6) 0 (0.0) 0 (0.0) 0 (0.0)	1 (0.8) 0 (0.0) 2 (1.6) 1 (0.8) 4 (3.3)	1.00 [a] 0.19 [a] 1.00 [a] 1.00[a] 1.00 [a]
Phenylpyrazole	Fipronil	1 (3.6)	3 (2.5)	0.56 [a]
Phenylpyrazole/Neonicotinoids	Fipronil/Imidacloprid	0 (0.0)	1 (0.8)	1.00 [a]
Pyrethroid	Cypermetrin Deltamethrin Lambda cyhalothin	3 (10.7) 0 (0.0) 2 (7.1)	10 (8.2) 6 (4.9) 9 (7.4)	0.71 [a] 0.59 [a] 1.00 [a]

Quinolinecarboxylic acid	Quinclorac	0 (0.0)	3 (2.5)	1.00 [a]
Ryanoid	Chlorantraniliprole	6 (21.4)	30 (24.6)	0.72 [b]
Strobilurin/Azole	Trifloxttrobin/Tebuconazole	0 (0.0)	3 (2.5)	1.00 [a]
Sulfonylurea	Bensulfuron-Methyl Chlorimuron-Ethyl Metsulfuron –Methyl	0 (0.0) 0 (0.0) 0 (0.0)	1 (0.8) 1 (0.8) 2 (1.6)	1.00 [a] 1.00[a] 1.00 [a]
Sulfonylurea/Quinolinemonocarboxylic	Bensulfuron-methyl/Quinolorac	0 (0.0)	1 (0.8)	1.00 [a]
Sulfonylurea	Metsulfuron-Methyl/Bensulfuron methyl	0 (0.0)	1 (0.8)	1.00 [a]
Thiadizine	Bentazone Buprofezin	0 (0.0) 0 (0.0)	1 (0.8) 4 (3.3)	1.00 [a] 1.00 [a]
Thiadizine/Nereistoxin	Buprofezin/Cartap hydrochloride	0 (0.0)	2 (1.6)	1.00 [a]
Triazines	Pymetrozine	0 (0.0)	6 (4.9)	0.6 [a]
Triazole/ Dioxolanes	Difenononazol/Propiconazol	0 (0.0)	4 (3.3)	1.00 [a]
Urea	Diafenthiuron	1 (3.6)	1 (0.8)	0.34 [a]
White oil	White oil	0 (0.0)	1 (0.8)	1.00 [a]
Illegal pesticide	Illegal pesticide	0 (0.0)	1 (0.8)	1.00 [a]

[a] P value by Fisher Exact test, [b] P value by Chi-Square test

Table 6.7: Associations between the pyrexial factor occurring 48 hours after spraying and pesticide algorithm intensity score, DREAM scores and urine metabolite

Variable	Pyrexial factor		
	Yes (n=28)	No (n=122)	P value
EFS score Median (Q1-Q3)	150.9 (103.4-251.8)	151.1 (107.8-230.8)	0.82 [c]
AHS score Median (Q1-Q3)	2.4 (2.4-3.8)	2.4 (2.3-2.5)	0.89 [c]
DREAM scores (n=130) Median (Q1-Q3)	59.1 (38.3-82.9)	89.0 (40.7-128.9)	0.12 [c]
Level of urinary metabolites (n=25), n (%) [a]			1.00 [d]
High/Very high	1 (33.3)	11 (50.0)	
Minimal/Low	2 (66.7)	11 (50.0)	
Difference between post and pre level of PBA (n=25), n (%) [b]			0.96 [d]
High	1 (33.3)	7 (31.8)	
Low	2 (66.7)	15 (68.2)	
Difference between post and pre level of dCVA (n=25), n (%) [b]			0.92 [d]
High	1 (33.3)	8 (88.9)	
Low	2 (66.7)	14 (63.6)	
Difference between post and pre level of TCP (n=25), n (%) [b]			0.81 [d]
High	1 (33.3)	9 (40.9)	
Low	2 (66.7)	13 (59.1)	

[a] High/Very high is when two scores above the median or all differ scores above the median and Minimal/Low is when scores always below the median or only one score above the median, [b] High is when the level above the median and low is when the level below the median, [c] P value Mann-Whitney U test, [d] P value by Fisher Exact test

Table 6.8: Predictors for pyrexial factor among the farmers

Variable	Simple logistic regression		Multiple logistic regression [a]	
	Crude OR (95% CI)	P value	Adjusted OR (95% CI) [b]	P value
Wore face shields	5.35 (2.13, 13.47)	<0.01	2.90 (1.01, 8.71)	<0.05
Wore chemical resistant boots	0.30 (0.11, 0.77)	0.01	0.23 (0.08, 0.70)	<0.01
Chest, back and abdomen exposed to pesticide	2.50 (1.02, 6.11)	0.04	1.74 (0.51, 5.90)	0.38
Legs exposed to pesticide	3.15(1.24, 8.00)	0.02	1.58 (0.46, 5.39)	0.46
Washed equipment	0.41 (0.18, 0.94)	0.04	0.39 (0.14, 1.05)	0.06

[a] Backward LR Multiple Logistic Regression model was applied, multicollinearity and interaction term were checked and not found, Hosmer-Lemeshow test (p=0.84) was applied to check the model fit
[b] Adjusted with age - Adjusted OR=0.97, (95% CI=0.93, 1.01), marital status – Adjusted OR=1.08, (95% CI=0.28, 4.20) and income – Adjusted OR=2.26 (95% CI=0.74, 6.92)

multiple causes. Hence, it is difficult to determine whether the symptoms can be entirely attributed due to pesticide exposure or due to other risk factors and there is no strong definitive evidence either way.

The symptoms reported also varied during the spraying week possible because there were repeated farmers who sprayed two- or three-times during spraying week, where the symptoms were only produced after repeated exposure to pesticide. However, this study did not find an association between level of urine metabolites and pyrexial factor. Another notable finding from this study is that used of fentin acetate was associated with pyrexia factor. However, no published studies have reported this association.

In a study conducted in Indonesia, PPE use was associated with reduced acute health symptoms. However, this study did not specify the type of PPE (68). This is consistent with the result of this study where certain types of PPE were associated with pyrexia symptoms. The risk of having the pyrexial factor decreased when the farmers used chemical resistant boots and increased when they wore face shields. Chemical resistant boots are recommended to use while working with pesticides, especially liquid based ones, because the pesticide will run off immediately and the residual pesticide can be easily removed after application. Hence, chemical resistant boots use will minimize dermal exposure and provide adequate protection towards pesticide (222). Face shields is one of the PPE used to protect eyes and full face if accidently happen during pesticide handling such as during liquid splashes. However, this study found contradictory results on face shields, where the used of face shields associated with pyrexial factor.

6.3.3 Strengths and weaknesses of the study

This study is one of the few studies exploring acute health effects following pesticide exposure among farmers in Malaysia. Hence, the result will provide more information on this issue. This study also collected information on health effects based on seven days diary which provide extensive data on acute health effects compared to many studies in Malaysia where the symptoms were collected at one point of time

(44,131,132). Strength is that the study population come from the same ethnic group (Malay) which is more homogenous and has less genetic differences.

This study has some limitations that warrant further discussion and need to be noted. First, self-reported exposure and health information is not a gold standard but a relatively simple method of obtaining information. Therefore, it remains unclear how accurate and reliable these self-reported exposures and health issues are. Farmers may have exaggerated or under-reported any symptoms. Hence this study is like the vast majority of previous epidemiological studies as it has relied on self-reported health symptoms and thus it may suffer from bias because this information relies only on the participants' perception. Secondly, recall bias is also possible because the inability of farmers to recall the symptoms in one week in retrospect. To make it worse, majority of the farmers answered the diary at the end of the seven days. However, questionnaires are an essential way to collect information on health symptoms. In this study, the farmers were exposed to wide range of pesticides which made it difficult to assess which pesticides produced the adverse health effects.

6.3.4 Potential implications and future research

Even though the symptoms reported among the farmers in this study can be classified as mild, evidence from other studies suggest that pesticide exposure may cause ill-health in farming population (9,10,138). So, health care providers need to be aware of pesticide exposure health risks especially those working with agricultural populations. In addition to that, medical records need to be updated with farmer's occupation in order to assist in the early detection of long- and short-term health effects of pesticide exposure. Looking at farmer's point of views, the farmers and their families should have recognized what is the sign and symptoms of pesticide poisoning. This will allow prompt treatment if this happen and prevent further serious injury. From public health point of view, estimating and monitoring the prevalence of acute pesticide poisoning is essential for proper plan prevention strategies, intervention and policies.

Moreover, the high-quality prospective study is crucial in order to plan for proper public health interventions. It is evident that the current study has limitations that need to address and further work is required to better delineate to what extent pesticide exposure may contribute to ill health. A future study should verify the self-reported symptoms by more objective measurement such as a proper physical examination and vital sign check such as temperature and blood samples to measure kidney and liver function for example. In addition, despite the self-reported nature of the questionnaire the research team sometimes needed to obtain the daily health symptoms by a telephone interview.

It is important for a future study need to look at single type of chemical class such as OPs in relation to the development of health symptoms. A future study should also consider dermatological symptoms which was not included in this current study. There also need to for research on the effect of fentin acetate in causing pyrexial factor. In addition to the agricultural workers, their family members especially those who are more vulnerable such as children, elderly and women should be investigated.

6.4 CONCLUSION

In conclusion, acute ill-health symptoms were common and varied among farmers. Farmer's PPE use was significantly associated with decreased or increased risk of having the pyrexial factor. Therefore, an effort from governmental and non-governmental organisations is needed to educate the farmers and public and increase their awareness and understanding of the health risks associated with pesticide exposure at individual, family and community levels.

CHAPTER 7: OVERALL DISCUSSION

7.1 INTRODUCTION

Pesticide use in low- and middle-income countries is increasing due to food security issues and ensures local agricultural production even though it could produce adverse health impacts to the populations in agricultural communities. The adverse effects associated with pesticide exposure have emerged as a major public health challenge. Unfortunately, the acute health effects following pesticide exposure among occupationally exposed is underreported and the true burden of the disease remains unknown especially in developing countries.

This study aimed to assess exposure to pesticides and investigate the potential acute health effects of pesticides among small scale farmers in Malaysia. To address these aims, a cohort study of Malaysian farmers was conducted in two districts on the East Coast of Malaysia, which is a main agricultural area in Malaysia. This study focussed mainly on male small holder farmers and consisted of pilot and main study. The pilot study (Chapter 3) focussed on the feasibility to conduct the field research in Malaysia. Meanwhile, the main study focussed on exposure assessment (Chapter 4) and acute health effects of pesticide exposure (Chapter 6). In addition, knowledge and practice of pesticide use and associations between PPE use, demographics and pesticide use were presented (Chapter 5).

7.2 OVERALL FINDINGS

The overall findings of this thesis will be discussed with reference to the specific objectives from each chapter and summaries of main results are shown in Table 7.1.

The main focus of this study can be divided into two which are exposure assessment and ill health effects particularly acute effects. Aims 1-5 cover exposure assessment and aims 9-12 cover ill-health effects. In addition, this thesis also discussed on knowledge and practice of pesticide use (aims 6-8).

Table 7.1: Summary of main findings

Aim	Findings
1) To quantify the level of urine metabolites pre- and post-spraying and determine the relationship between the level of urine metabolites, demographic factors and pesticide exposure (Chapter 4)	The difference between post- and pre-spraying and post-spraying urine samples of chlorpyrifos. pyrethroids and cypermetrin were higher among farmers who used the pesticides and this was not observed among farmers who not used it (Refer section 4.2.2.3.2). The farmers who used power sprayer/blower and who had their head or face exposed were more likely to have high level of urinary metabolites (Refer section 4.2.3.4).
2) To adapt existing AHS and EFS pesticide exposure intensity algorithm models to the study population to estimate pesticide exposure intensity (Chapter 4)	The rice farmers have higher EFS level compared to vegetable/rice farmers ($p<0.01$). (Refer section 4.2.2.1).
3)To estimate current pesticide exposure based on dermal exposure using (DREAM) (Chapter 4)	Exposure occurs more during spraying than mixing and during spraying, rice farmers are exposed more than vegetable/fruit farmers. During mixing, vegetable/fruit farmers are exposed more than rice farmers (Refer section 4.2.2.2.2).
4)To determine the correlation between the DREAM score and AHS and EFS pesticide exposure intensity algorithm model scores (Chapter 4)	Between EFS and AHS, there was a moderate positive correlation (Refer section 4.2.3.3).
5)To determine the associations between pesticide exposure intensity scores and DREAM scores and demographics (Chapter 4)	Lower income farmers had higher DREAM scores compared to higher income farmers. There were no other association between pesticide algorithm intensity scores and DREAM scores and demographic factors (Refer section 4.2.3)
6)To assess knowledge and practice of pesticide use among the farmers (Chapter 5)	More vegetable/fruit farmers had good practice scores of pesticide use compared to rice farmers. The number of rice and vegetable/fruit farmers who had good knowledge scores of pesticide use was almost similar between two groups. (Refer section 5.2.1)
7)To determine the associations between knowledge and practice of pesticide use and demographics and pesticide exposure (Chapter 5)	A poor knowledge score of pesticide use was associated with not using PPE, repairing equipment after pesticide use and being a bystander farmer. (Refer section 5.2.1.7) A poor practice score of pesticide use was associated with duration of spraying more than one day, did not re-entry into a sprayed field and not wash equipment. (Refer section 5.2.1.7)
8)To determine the associations between PPE use and demographic and pesticide exposure (Chapter 5)	PPE use was associated with increase used of power sprayer/blower and did not re-enter into field being sprayed. (Refer section 5.2.2.6)
9)To determine the nature and prevalence of self-reported acute health symptoms occurring 48 hours during a spraying week	1 in 3 of farmers reported a health symptom after spraying pesticide and this was more common among rice farmers (Refer section 6.2.2).

(Chapter 6)	
10)To examine the association between self-reported acute health symptoms occurring 48 hours of spraying and demographics and pesticide exposure 48 hours after pesticide spraying (Chapter 6)	Used of chemical resistant boots was associated with reduce pyrexial factor. However, used of face shields was associated with increased pyrexial factor (Refer section 6.2.4.5).
11)To investigate the nature of ill-health (Chapter 4)	1 in 3 farmers reported average/poor general health and the most common self-reported issue was high blood pressure (Refer section 4.2.4).
12)To estimate the prevalence of somatic and neuropsychiatric ill-health including Parkinsonism, neuropathy, depression and dementia (Chapter 4)	Nearly half of the farmers reported of being bothered at all by somatic symptoms. Among the neuropsychiatry symptoms, the prevalence of being bothered at all by Parkinsonism and neuropathy symptoms was the highest followed by the prevalence of being bothered at all by depression symptoms and the prevalence of being bothered at all by dementia symptoms was 16%. There were no differences between percentage of symptoms and type of farming (Refer section 4.2.5).
13)To examine the associations between ill health and demographic factors and pesticide exposure (Chapter 4)	The average/poor general health was associated with duration of spraying of one day per week (Refer section 4.2.7.1). High blood pressure, being bothered at all of Parkinson/neurology and depression were associated with an incident while using pesticide (Refer section 4.2.7.2, section 4.2.7.3, and section 4.2.7.4). Being bothered at all by somatic and dementia were not associated with any pesticide exposure (Refer section 4.2.7.5 and section 4.2.7.6).

Quantification of pesticide exposure in occupationally exposed populations is crucial to investigate their potential adverse health effects in farmers. Exposure and health effects of pesticides among farmworkers in Malaysia have not been adequately assessed and very limited published data is available. As highlighted in the literature review, many studies conducted in developing counties have relied on self-reported pesticide rather than others exposure assessment sources. For exposure assessment, this study designed based on a combination method of exposure assessment that included direct and indirect methods.

The farmers who participated in this study experienced occupational exposure to pesticides. A high proportion of farmers who participated in this study had detectable urinary levels of chlorpyrifos, pyrethroid or cypermethrin metabolites. Farmers who reported using chlorphyrifos, pyrethroid or cypermethrin were more exposed to these pesticides than other farmers who did not report using the specific pesticide where the significant difference between post- and pre-spraying urine metabolite levels among farmers who reported using chlorphyrifos, pyrethroid or cypermethrin and also the significant difference between farmers who reported using and not using chlorphyrifos, pyrethroid or cypermethrin and difference of post- and pre-spraying urine metabolites were reported. The farmers in Malaysia sprayed pesticides all year round. This could lead to extended exposure and pesticide load in body.

The use of power sprayer/blowers and exposed head or face was associated with high urine metabolites. The possible mechanism is that the power sprayer/blowers produce more pesticide mist during spraying compared to backpacker sprayer. Another possible explanation is due to leaking of power sprayer/blowers which increases the risk of exposure through dermal exposure from skin and also contaminated clothes. The level of urine metabolite was high in farmers who had their head or face exposed. An increased risk of expose may occur due to proximity of the head/face to the pesticide mist produced by the power sprayer/blower and also because of the lack of adequate work clothing covering head or face.

The DREAM scores were calculated in order to semi-quantitatively calculate dermal exposure. The farmers were exposed to pesticide during mixing and spraying. However, this study found that, high exposure was during spraying and there was a difference in exposure among the type of farming and the tasks they do. For instance, the vegetable/fruit farmers were more exposed during mixing and rice farmers more exposed during spraying. During mixing, hands were more exposed than other parts of the body due to the hand holding the cup when the farmers pour the pesticide in and the emission of pesticide occurred during that time. Figure 7.1 shows the farmers used bare hand to hold the cup to pour the pesticide. However, during spraying other parts of the body were exposed to pesticide either though transfer or deposition.

This thesis provides some additional knowledge and understanding regarding acute and chronic health especially high blood pressure, somatic and neuropsychiatry symptoms. The initial plan was to focus on reproductive effects among men by collecting semen samples. However, results from the pilot study showed that it was not feasible to collect semen samples. Further details have been described in Chapter 3.

Figure 7.1: The farmer used bare hand to hold the cup to pour the pesticide

Acute ill-health effects were seen in this study where 1 in 3 farmers reported at least one symptom and this was more common among rice farmers. This study found a variation in the self-reported symptoms and the most reported symptoms were feeling unusually tired, feeling sweaty, shivery and feverish and having a headache. However, the symptoms were not specific to a pesticide and might be due to other causes such as the hot climate or ergonomic problems from carrying heavy spraying equipment or are the result of existent health problems. This is because most of reported symptoms occurred on days 1-2 and the acute health symptoms are rather non-specific, may not be necessarily pathological and can have multiple causes. Hence, it is difficult to determine whether the symptoms can be entirely attributed due to pesticide exposure or due to other risk factors and there is no strong definitive evidence either way.

Univariable analysis showed fentin acetate was associated with pyrexia factor. However, other active ingredients were not associated with pyrexial factor. The results were striking but the underlying reasons are not clear. Currently there is no strong epidemiological evidence of health effects related to fentin acetate usage. Factors that contribute to pyrexial factors include used of face shields (increased risk) and chemical resistant boots (reduce risk). The face shields can increase risk if the pesticide mist splash to the face shields and it will stay and the farmers touch and did not wash the face shields. Consequently, the face shields will increase risk of exposure. The farmers must be cautious with this and if the pesticide splashes the face shields, the shields need to be rinse thoroughly.

At the study baseline, 70.0% of the farmers reported good or very good health condition and high blood pressure was the most common illness among the farmers. Nearly half of the farmers reported being bothered at all by somatic symptoms. Among neuropsychiatry symptoms, being bothered at all by Parkinsonism and neuropathy was the most reported symptoms followed by being bothered at all by dementia symptoms and then depression symptoms. This study illustrated that acute or chronic low dose pesticide exposure potentially results in chronic health problems. This was achieved by considering incidents while using pesticide variable as a proxy for acute exposure. Incidents while using pesticide was associated with Parkinsonism/neurology and depression symptoms. An" incident" whilst using a pesticide potentially reflects a high pesticide exposure event and hence is potential on a causal pathway and this could be associated with length of time working as there is more opportunity to have an incident (146). Further work is required to determine whether this association reflects indeed a high pesticide exposure event.

In term of knowledge score of pesticide use, there was no difference between rice and vegetable/fruit farmers. But, a difference was observed in practice scores of pesticide use where more rice farmers had a poor score. The rice farmers showed relatively lower practice scores than vegetable/fruit farmers, which was most likely due to environment or condition of rice farmers working in muddy and shared spraying areas with other farmers. Figure 7.2 shows the vegetable farmer doing spraying in dry area and Figure 7.3 shows the rice farmers mixing pesticide in the muddy area. Being a bystander farmer, did not using PPE and repairing spraying equipment were associated with poor knowledge scores and duration of spraying more than one day, did not re-entry into a sprayed field and not wash equipment were associated with poor practice scores.

This study also emphases that different types of farming will have difference types of exposure which can lead to different health effects. This study found that the rice farmers had higher exposure from results of urine metabolites level, EFS scores and DREAM score which lead to high prevalence of acute il-health symptoms and being bothered at all of somatic and neuropsychiatry symptoms.

Figure 7.2: The vegetable farmer doing spraying in dry area

7.3 OVERALL STRENGTHS, LIMITATIONS AND RECOMMENDATION FOR FUTURE RESEARCH

The study thesis has a number of strengths. To my knowledge, this is the first study in Malaysia that measured exposure by using various urine metabolites as biomarkers and examines pesticide exposure and somatic and neuropsychiatric symptoms. Convenience sampling was used as a study sampling method. This technique widely used in qualitative research where the target sample population meet certain criteria such as easy accessibility, geographical proximity and availability at a given time (233). This study also used a wide range of questions to obtain information on occupational histories and working practices that were collected through interview led questionnaire. In addition, the acute health symptoms were collected for a week.

In systematic review conducted by IMPRESS team, 40% of the studies used direct and indirect methods to assess exposure to pesticide (73). This study also using multiple exposure assessment method which includes combination of direct and indirect methods. Used of multiple EAM will counterbalance the weaknesses of one exposure assessment method with the strengths of another.

Figure 7.3: The rice farmer mixing the pesticide in the muddy area and not wearing gloves while handling pesticide which will increase the exposure

Acute occupational pesticide related illness (AOPI) surveillance is vital to preventing work-related illness. This will provide a better understanding and identify high-risk groups, high-risk pesticides and the root causes through exploration of the assessment of pesticide exposure and health impact due to pesticide exposure.

In addition, it may also help to reduce pesticide exposure and improved health status among farmers in Malaysia by determining the principal routes of exposure as the previous study among Thai farmers indicated that direct transfer of pesticides from farmers could increase familial exposure to pesticides (234). Therefore, the outcome of this research will be useful for researchers to provide advice for improvement for future research in this field. It also may offer new perspectives and benefits to the authorities and stakeholders to improve the current policies and the process of pesticides management in Malaysia.

The Sustainable Development Goals or Global Goals are the blueprints for achieving a better and more sustainable future for all. To leave no one behind, including farming communities, it is essential to make them by 2030. Looking at United Nation Sustainable Development Goals (SDGs), this study in line with SDG number 2 (zero hunger), 3 (good health and wellbeing), 8 (decent work and economic growth), 15 (life on land) and 17 (partnership for goals).

The present study analysis should he interpreted in the light of study's limitations and should be acknowledged for better of future study. The used of questionnaires in assessing exposure and outcome prone to various type of bias such as misclassification and recall bias. This study relies on farmer's recall of pesticide exposure, misclassification bias is likely to be considered. Recall bias occur when relying on self-reported exposure and symptoms. Furthermore, the farmers may not be interested in sharing their symptoms. The data of health symptoms from this study were reliant on self-perception and further study is needed to explore these symptoms by doing physical examination.

As explained above, the study population was not randomly selected. This could be source of selection bias, as no random selections of farmers from the total population were made. This will limit the study conclusion. The sampling frame for this study involved only a single state in Malaysia. So, the results cannot be generalised and may not reflect the entire population of the study area. It is likely that working practices may vary between workers. With respect to future research, conducting a similar study in a wider and larger geographical area with an increased sample size would be of some benefit. Since this study is based on cross sectional data without the objective of this study was a control or unexposed group, further studies also need to have a control or unexposed group such as sample from general population. The study could have been strengthened by including a control group and the control group maybe the man who was not occupational exposed to the pesticide.

In term of sample size for main study, following the pilot study, an amendment to UoM UREC1 was submitted with a few proposed changes. Specifically in relation, it was noted that during the pilot study, none of the participants gave consent for semen sample collection. The proposed change was that participation in the study was not to be made contingent on collection of the semen sample. Semen sample collection was made optional. No change in sample size was made nor requested by UREC1. In hindsight, it is likely that the study was underpowered and less likely to detect a true effect (235), but the data obtained from this study could be used to better design a study to highlight any possible non-reproductive health effects.

In this small-scale farming, housing areas are generally located near to the farming area. Hence, pesticides not only involve agricultural workers but also their families including women, children and elderly and they may have secondary pesticide exposure. A study on OP exposure among family members in an agricultural community in Thailand showed that they are exposed to pesticides in the spraying season and the main route of exposure is dermal (234). The family members can get their exposure from farmers at home if they return home with working clothes, washing and cleaning clothes and equipment in the home, mixing and storing pesticides at home. Additionally, in developing countries it is common that the children help their parents in doing agricultural work tasks. Hence, future research should aim to quantify pesticide exposure on the farm and in the homes of farming and non-farming families.

A single type of pesticide such on organophosphate may provide more information on exposure and for further investigation future research should look at the most common types of pesticides used rather than the diverse collection in this study. This would make analyses more specific and easier make comparisons. Monitoring personal air for pesticides may also give better understanding about the pesticide exposure. Measuring pesticide concentration 24 hours at difference distances from the field, to quantify the concentration of pesticides in air samples would help to provide information as to what extent pesticide emissions result in exposure (236). Up to now, very little research has been carried out on the concentration of pesticides via personal air sampling. Thus, the pesticide exposure outside working hours will be not considered.

This study was not designed to elucidate the molecular mechanism underlying associations between health effects and pesticide exposure. In addition to biomarkers of exposure and effect, the future study also needs to look at genetic susceptibility such as paraoxonase (PON1) and cytochrome P450s as well. This study has shown fentin acetate exposure associated with pyrexial factor. It is vital that future studies should look at specific fentin acetate exposure in order to provide further information on any potential association between fentin acetate and health problems.

7.4 IMPLICATION FOR FARMERS AND HEALTH CARE PROVIDERS TO MINIMISE THE HAZARDS OF PESTICIDES

The smallholder farmers in Malaysia have struggled to use pesticides safely and effectively due to a lack of awareness and knowledge and poor attitude among them (224,237). Moreover, to make it worse, this has occurred because of a lack of training and good monitoring and guidelines for pesticide use in the country. In Malaysia, pesticide use is not a priority for environmental issues. This is because pesticides are widely used among small and medium enterprises only and not among large enterprises, to which the government pays more attention. In addition, most work in Malaysia has focused on other environmental health issues such as air pollution. Consequently, the effects of pesticide exposure are under-reported. This thesis has demonstrated that pesticide exposure exists among occupational populations. Hence, results from this thesis provides a unique opportunity for the development of future research and interventions.

The risk due to pesticide exposure is unavoidable but there is a need to reduce risk. To achieve the goal of reducing pesticide exposure and protect farmers from pesticides several recommendations or steps are proposed for developing a paradigm shift of pesticide control in Malaysia. In order to minimise the hazards, this study provides a few recommendations.

In a study conducted in Northern Greece showed that farmers' training on pesticide use is significantly associated with increased safety behaviour (238). Proper educational training programs especially focussing on work practice and use of PPE, hygiene measures and safety precautions especially on reading the label, are possible interventions that could be designed. This is to ensure that the farmers understand the health-related hazards of pesticide use. If possible, the training provided needs to be done in the local language, so it is easy for farmers to understand it. This study may have important scientific implications for health care providers. At the moment, training to recognize and deal with pesticide poisoning among health care providers is still lacking. Hence, health care providers are recommended to improve training on management and prevention of pesticide related health risks which include occupati onal risk assessment, diagnosis and assessment including differential diagnosis, common sign and symptoms, initial treatment and referral and prevention of pesticide poisoning. Following this study, an education workshop had been conducted in November 2020 by Crop Life Asia among the farmers. The workshop aimed to educate the farmers on safety while handling pesticide. This is as a precaution to reduce pesticide exposure in the absence of strong details about ill health effects among the farmers.

7.5 FINAL CONCLUSION

The results presented in this thesis have provided valuable information regarding occupational exposure to pesticides and possible health risk related to the exposure. A remarkable finding was that exposure to pesticides was observed among farmers in

Malaysia based on assessment such as urine metabolites, pesticide exposure intensity score and DREAM score parameters. Reporting of health symptoms including acute and chronic were observed. However, there was no sufficient evidence to say this is due to exposure to pesticide. This also possible due to other problems or is due to chance.

However, this finding can serve as a foundation for further pesticide studies in Malaysia. In the field of occupational hygiene, the data from this study provides new information about exposure assessment and can contribute to the development of better exposure assessment approaches in epidemiologic studies of pesticides especially in developing countries. Overall, there are several recommendations to address the pesticide problems such as campaigns, education and training and they are required to improve understanding about the health risks of exposure. Hence, a cohort study incorporating outcomes and measurement of exposure on a large-scale should be conducted.

REFERENCES

1. Malaysia: Leading Environmental Issues 2019: https://www.statista.com/statistics/malaysia-leading-environmental-issues
2. Pesticide Use by Country - Worldometer: https://www.worldometers.info/food-agriculture/pesticides-by-country
3. Sharma A, Kumar V, Shahzad B, Tanveer M, Sidhu GPS, Handa N, et al. Worldwide pesticide usage and its impacts on ecosystem. SN Appl Sci ;1(11):1–16
4. Zhang W. Global pesticide use: Profile, trend, cost, benefit and more. Vol. 8, Proceedings of the International Academy of Ecology and Environmental Sciences. 2018
5. Malaysia Employment in agriculture - data, chart | TheGlobalEconomy https://www.theglobaleconomy.com/Malaysia/Employment_in_agriculture
6. Malaysia Agricultural Land Percent Of Land Area: https://tradingeconomics.com/malaysia/agricultural-land-percent-of-land-area
7. Gunnell D, Eddleston M, Phillips MR, Konradsen F. The global distribution of fatal pesticide self-poisoning: Systematic review. BMC Public Health. BioMed Central. 2007;7(2):74-7
8. Nganchamung T, Robson MG, Siriwong W. Association between blood cholinesterase activity, organophosphate pesticide residues on hands, and health effects among chili farmers in Ubon Ratchathani Province, northeastern Thailand. Rocz Panstw Zakl Hig. 2017 Jan 1;68(2):175–83
9. Sapbamrer R, Nata S. Health symptoms related to pesticide exposure and agricultural tasks among rice farmers from northern Thailand. Environ Health Prev Med. 2014 Jan;19(1):12–20
10. Neupane D, Jors E, Brandt L. Pesticide use, erythrocyte acetylcholinesterase level and self-reported acute intoxication symptoms among vegetable farmers in Nepal: A cross-sectional study. Environ Heal A Glob Access Sci Source 2014 Dec 20;13(1):98
11. Petrovitch H, Webster Ross G, Abbott RD, Sanderson WT, Sharp DS, Tanner CM, et al. Plantation work and risk of Parkinson disease in a population-based longitudinal study. Arch Neurol. 2002 Nov 1;59(11):1787–92
12. Narayan S, Liew Z, Bronstein JM, Ritz B. Occupational pesticide use and Parkinson’s disease in the Parkinson Environment Gene (PEG) study. Environ Int. 2017;107:266–73
13. Eriguchi M, Iida K, Ikeda S, Osoegawa M, Nishioka K, Hattori N, et al. Parkinsonism Relating to Intoxication with Glyphosate. Intern Med;58(13):1935–8
14. Hossain F, Ali O, D’Souza UJA, Saw Naing DK, Naing DKS. Effects of pesticide use on semen quality among farmers in rural areas of Sabah, Malaysia. J Occup Health. 2010;52(6):353–60
15. Krstev S, Knutsson A. Occupational Risk Factors for Prostate Cancer: A Meta-analysis. J Cancer Prev. 2019 Jun 30;24(2):91–111
16. Dreiher J, Kordysh E. Non-Hodgkin lymphoma and pesticide exposure: 25 Years of research. Vol. 116, Acta Haematologica. 2006;116(2):153–64

17. Food and Agriculture Organization of the United Nations. The International Code of Conduct on Pesticide Management. Food Agric Organ United Nations http://www.fao.org/fileadmin/templates/agphome/documents/Pests_Pesticides
18. Prieto Garcia F, Cortes Ascencio SY, Oyarzun JCG, Hernandez AC, Alavarado PV. Pesticides: classification, uses and toxicity. Measures of exposure and genotoxic risks. J Res Environ Sci Toxicol. 2012;1(11):2315–20
19. US EPA OCADIS. Insecticides introduction | CADDIS: Sources, Stressors & Responses | US EPA. 2009
20. Heong KL (Kong L, Escalada MM, International Rice Research Institute. Pest management of rice farmers in Asia. IRRI; 1997. https://books.google.co.uk
21. Distinguish between selective and non-selective herbicides and give an example of each. | Forage Information System | Oregon State University :http://forages.oregonstate.edu/nfgc/eo/onlineforagecurriculum/instructormaterials/availabletopics/weeds/herbicides
22. Wan Zainal Azman Wan Abdullah. General classification of pesticides: Rodenticides: http://www.prn.usm.my/old_website/mainsite/bulletin/sun/1997
23. Stamps RH, Osborne LS. Selected Miticides for Use on Ornamental Plants: http://mrec.ifas.ufl.edu/lso/SpMite
24. Chemical Nematicides for Control of Plant-Parasitic Nematodes in Georgia Vegetable : https://extension.uga.edu/publications
25. Molluscicides U.S. Army Corps of Engineers Building Strong
26. The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification 2009. International Programme on Chemical Safety. 2010: http://www.who.int/ipcs/publications/pesticides_hazard_2009.pdf
27. Aktions-Netzwerk eV P. Pesticides and health hazards - Facts and figures: http://www.pan-germany.org/download/
28. US EPA, OCSPP O. Basic Information about Pesticide Ingredients. US EPA. 2011
29. Carullo P, Cetrangolo G, Mandrich L, Manco G, Febbraio F. Fluorescence Spectroscopy Approaches for the Develoment of a Real-Time Organophosphate Detection System Using an Enzymatic Sensor. Sensors. 2015 Feb 9;15(2):3932–51
30. International Program on Chemical Safety. Organophosphorus insecticides: A general introduction. World Health Organization; 1986. 181: http://www.inchem.org/documents
31. Delaware Health and Social Services D of PH. Organochlorine Pesticides. dhss.delaware.gov/dhss/dph/files/organochlorpest.pdf
32. Health Unit E, Health Branch P. Carbamate Insecticides – Fact sheet. 2002: https://www.health.qld.gov.au
33. Pyrethroid Insecticide: http://www.idph.state.il.us/envhealth/pyrethroid.htm
34. Malaysia Maps | Maps of Malaysia: http://ontheworldmap.com/malaysia/
35. Rozhan Abu Dardak. Transformation of Agricultural Sector in Malaysia Through Agricultural Policy. FFRC Agricultural Policy Articles.2015: http://ap.fftc.agnet.org/ap_db
36. Rahman ZA. Agricultural Research And Development in Malaysia. J. ISSAAS. 2012;18(2):176-82

37. U NM, Ismail SS, A EZ. Pesticide application, dermal exposure risk and factors influenced distribution on different body parts among agriculture workers. Malaysian J. Public Health Med.2017;17(1):123-32
38. Department of Statistics Malaysia Official Portal. Selected Agricultural Indicators, Malaysia,2018 https://www.dosm.gov.my/v1
39. Malaysia’s Agrofood Policy (NAP 2011-2020)- Performance and New Direction :http://ap.fftc.agnet.org/ap_db
40. Aktar MW, Sengupta D, Chowdhury A. Impact of pesticides use in agriculture: their benefits and hazards. Mar Interdiscip Toxicol. 2009;2(1): 1–12
41. FAOSTAT. Pesticides indicators in Malaysia :http://www.fao.org/faostat/en
42. Md Sufian Yek Bin Md Juni Yek. Proceedings of the Asia regional workshop on the implementation, monitoring and observance of the international code of conduct on the distribution and use of pesticides: http://www.fao.org/docrep
43. HalimatunsadiahA. B, Mazlan N, Omar D, Kamarulzaman NH. Application of pesticide in pest management: the case of lowland vegetable growers. Int. Food Res. J. 2016;23(1): 85-94
44. Hamsan H, Ho Y Bin, How V, Hashim Z, Saari N. A Survey on Pesticide Use and Self-Reported Respiratory Health Symptoms Among Paddy Farmers in Tanjung Karang, Malaysia. Mal J Med Heal Sci;14(SP1):56–63
45. D H Brouwer, E J Brouwer, J J van Hemmen. Assessment of dermal and inhalation exposure to zineb/maneb in the cultivation of flower bulbs. Ann Occup Hyg. 1992 Aug;36(4):373-84
46. Frank R, Sirons GJ. Occupational Exposure of Herbicide Applicators to Herbicides Used Along Electric Power Transmission Line Right-of-Way. Am Ind Hyg Assoc J. 1984 Jan 1;45(1):56–62
47. Semple S. Dermal exposure to chemicals in the workplace: Just how important is skin absorption. Occup Environ Med. 2004 Apr; 61(4): 376–382
48. Macfarlane E, Carey R, Keegel T, El-Zaemay S, Fritschi L. Dermal exposure associated with occupational end use of pesticides and the role of protective measures. Saf Health Work. 2013 Sep;4(3):136–41
49. Cao L, Chen B, Zheng L, Wang D, Liu F, Huang Q. Assessment of potential dermal and inhalation exposure of workers to the insecticide imidacloprid using whole-body dosimetry in China. J Environ Sci (China). 2015 Jan 1;27(C):139–46
50. Wahlström J, Mathiassen SE, Liv P, Hedlund P, Ahlgren C, Forsman M. Predictive Exposure Modelling for Pesticide Registration Purposes. Ann Occup Hyg. 2010 Oct 1;54(5):584–94
51. Baldi I, Lebailly P, Jean S, Rougetet L, Dulaurent S, Marquet P. Pesticide contamination of workers in vineyards in France. J Expo Sci Environ Epidemiol. 2006;16(2):115–24
52. Schneider T, Vermeulen R, Brouwer DH, Cherrie JW, Kromhout H, Fogh CL. Conceptual model for assessment of dermal exposure. Occup Environ Med. 1999 Nov; 56(11): 765–73
53. Dowling KC, Seiber JN, Ames RG, DiBartolomeis MJ, LeNoir JS. Importance of Respiratory Exposure to Pesticides Among Agricultural Populations. Int J Toxicol. 2002;21:371–81

54. Christos A. Damalas, Spyridon D. Koutroubas. Farmers' Exposure to Pesticides: Toxicity Types and Ways of Prevention. Toxics. 2016;4:1–10
55. Muhammad Sarwar. The Dangers of Pesticides Associated with Public Health and Preventing of the Risks. Int J Bioinforma Biomed Eng.2015;1(2):130–6.
56. Chester G. Worker exposure: methods and techniques. In: Krieger R. Handbook of pesticide toxicology. 2nd edition. Carlifonia: Academic Press; 2001 p. 425.
57. Lekei E, Ngowi A V., London L. Acute Pesticide Poisoning in Children: Hospital Review in Selected Hospitals of Tanzania. J Toxicol. 2017;3(1):232-37
58. Curwin BD, Hein MJ, Sanderson WT, Barr DB, Heederik D, Reynolds SJ, et al. Urinary and hand wipe pesticide levels among farmers and nonfarmers in Iowa. J Expo Anal Environ Epidemiol. 2005 Nov;15(6):500–8
59. Hines CJ, Deddens JA, Coble J, Kamel F, Alavanja MCR. Determinants of captan air and dermal exposures among orchard pesticide applicators in the agricultural health study. Annals of Occupational Hygiene. 2011;55(1):620–33
60. Lebailly P, Bouchart V, Baldi I, Lecluse Y, Heutte N, Gislard A, et al. Exposure to Pesticides in Open-field Farming in France. Ann Occup Hyg. 2008 Nov 20;53(1):69–81
61. Saleh Abbassy MM. Farmer's Knowledge, Attitudes and Practices, and their Exposure to Pesticide Residues after Application on the Vegetable and Fruit Crops. Case Study: North of Delta, Egypt. J Environ Anal Toxicol. 2017;07(05):13-7
62. Baharuddin MRB, Sahid IB, Noor MABM, Sulaiman N, Othman F. Pesticide risk assessment: A study on inhalation and dermal exposure to 2,4-D and paraquat among Malaysian paddy farmers. J Environ Sci Heal Part B. 2011 Oct 12;46(7):600–7
63. Berthet A, Hopf NB, Miles A, Spring P, Charrière N, Garrigou A, et al. Human skin in vitro permeation of bentazon and isoproturon formulations with or without protective clothing suit. Arch Toxicol. 2014 Jan;88(1):77–88
64. Damalas CA, Eleftherohorinos IG, Damalas CA, Eleftherohorinos IG. Pesticide Exposure, Safety Issues, and Risk Assessment Indicators. Int J Environ Res Public Health. 2011 May 6;8(12):1402–19
65. Del Prado-Lu JL. Pesticide exposure, risk factors and health problems among cutflower farmers: A cross sectional study. J Occup Med Toxicol. 2007 Sep 18 ;2(1):9-13
66. Fait A, Iversen B, Tiramani M, Visentin S, Maroni M. Preventing Health Risks from the Use of Pesticides in Agriculture. Protecting Workers' Health Series.
67. Personal Protective Equipment – Pesticide Environmental Stewardship: https://pesticidestewardship.org/personal-protective-equipment
68. T J, NAY D, HL D. Pesticide Poisoning and the Use of Personal Protective Equipment (PPE) in Indonesian Farmers. J Environ Public Health. 2020;2020(1):21-8
69. Manyilizu WB, Mdegela RH, Helleve A, Skjerve E, Kazwala R, Nonga H, et al. Self-reported symptoms and pesticide use among farm workers in Arusha, Northern Tanzania: A cross sectional study. Toxics. 2017 Sep 27;5(4):54-9

70. Fenske RA, Schulter C, Lu C, Allen EH. Incomplete Removal of the Pesticide Captan from Skin by Standard Handwash Exposure Assessment Procedures. Vol. 61, Bull. Environ. Contam. Toxicol. 1998;61(2):194-201
71. Fenske RA, Lu C. Determination of Handwash Removal Efficiency: Incomplete Removal of the Pesticide Chlorpyrifos from Skin by Standard Handwash Techniques. Am Ind Hyg Assoc J. 1994;55(5):425–32
72. Total human exposure An emerging science focuses on humans as receptors of environmental pollution from: https://pubs.acs.org/sharingguidelines
73. Ohlander J, Fuhrimann S, Basinas I, Cherrie JW, Galea KS, Povey AC, et al. Systematic review of methods used to assess exposure to pesticides in occupational epidemiology studies, 1993-2017. Occup. Environ. Med. 2020;77(6):355-56
74. Maroni M, Colosio C, Ferioli A, Fait A. Biological Monitoring of Pesticide Exposure: A review. Introduction. Toxicology. 2000 Feb 7;143(1):1-118
75. Costa LG, Cole TB, Vitalone A, Furlong CE. Measurement of paraoxonase (PON1) status as a potential biomarker of susceptibility to organophosphate toxicity. Clin Chim Acta. 2005 Feb;352(2):37–47
76. Barr DB. Biomonitoring of exposure to pesticides. J Chem Heal Saf. 2008 Nov;15(6):20–9
77. He F. Biological monitoring of exposure to pesticides: Current issues. Toxicol Lett. 1999 Sep 5;108(3):277–83
78. Cotton J, Edwards J, Rahman MA, Brumby S. Cholinesterase research outreach project (CROP): Point of care cholinesterase measurement in an Australian agricultural community. Environ Heal A Glob Access Sci Source 2018 Apr 2;17(1):31-5
79. Dyer SM, Cattani MM, Pisaniello DL, Williams FM, Edwards JW. Peripheral cholinesterase inhibition by occupational chlorpyrifos exposure in Australian termiticide applicators. Toxicology. 2001 Dec 28;169(3):177–85
80. Coye MJ, Lowe JA, Maddy KT. Biological monitoring of agricultural workers exposed to pesticides:cholinesterase activity determinations. J Occup Med 1986;28(8):619–27
81. Cocker J, Mason HJ, Garfitt SJ, Jones K. Biological monitoring of exposure to organophosphate pesticides. Toxicol Lett. 2002;4(1):97–103
82. He F, Chen S, Tang X, Gan W, Tao B, Wen B. Biological monitoring of combined exposure to organophosphates and pyrethroids.Toxicol Lett. 2002.4(1):119–24
83. Barr DB, Wong LY, Bravo R, Weerasekera G, Odetokun M, Restrepo P, et al. Urinary concentrations of dialkylphosphate metabolites of organophosphorus pesticides: National Health and Nutrition Examination Survey 1999-2004. Int J Environ Res Public Health. 2011 Jul 25;8(8):3063–98
84. Bouvier G, Blanchard O, Momas I, Seta N. Environmental and biological monitoring of exposure to organophosphorus pesticides: Application to occupationally and non-occupationally exposed adult populations. J Expo Sci Environ Epidemiol. 2006 Sep 26;16(5):417–26
85. T.I Tengku Hanidza, M.Zain Sharifuddin, Juahir Hafizan, Yusoff M.Kamil, Abdul Manaf Latifah. Organophosphate Exposure: A Preliminary Assessment

On The Use Of Pesticide Intensity Score To Evaluate Exposure Among Fruit Growers. Environ. 2010 Jan;(3 (Special Issue)):203–126
86. Hanchenlaksh C, Povey A, O’Brien S, de Vocht F. Urinary DAP metabolite levels in Thai farmers and their families and exposure to pesticides from agricultural pesticide spraying. Occup Environ Med. 2011 Aug 1;68(8):625–7
87. Buchanan D, Pilkington A, Sewell C, Tannahill SN, Kidd MW, Cherrie B, et al. Estimation of cumulative exposure to organophosphate sheep dips in a study of chronic neurological health effects among United Kingdom sheep dippers. Occup Environ Med. 2001;58(11):694–701
88. Taneepanichskul N, Norkaew S, Siriwong W, Siripattanakul-Ratpukdi S, Maldonado Perez HL, Robson MG. Organophosphate pesticide exposure and dialkyl phosphate urinary metabolites among chili farmers in northeastern Thailand. Rocz Panstwowego Zakładu Hig. 2014;65(4):291–9
89. Vasilic Z, Drevenkar V, Stengl B, Fröbe Z, Rumenjak V. Diethylphosphorus metabolites in serum and urine of persons poisoned by phosalone. Chem Biol Interact. 1993 Jun;87(1–3):305–13
90. Connolly A, Jones K, Basinas I, Galea KS, Kenny L, McGowan P, et al. Exploring the half-life of glyphosate in human urine samples. Int J Hyg Environ Health. 2019 Mar 1;222(2):205–10
91. Acquavella JF, Alexander BH, Mandel JS, Gustin C, Baker B, Chapman P, et al. Glyphosate biomonitoring for farmers and their families: results from the Farm Family Exposure Study. Environ Health Perspect. 2004 Mar;112(3):321–6
92. Rendon-Von Osten J, Dzul-Caamal R. Glyphosate residues in groundwater, drinking water and urine of subsistence farmers from intensive agriculture localities: A survey in Hopelchen, Campeche, Mexico. Int J Environ Res Public Health. 2017 Jun 1;14(6):15-21
93. Jauhiainen A, Rasanen K, Sarantila R, Nuutinen J, Kangas J. Occupational exposure of forest workers to glyphosate during brush saw spraying work. Am Ind Hyg Assoc J 1991 Feb 1;52(2):61–4
94. Connolly A, Jones K, Galea KS, Basinas I, Kenny L, McGowan P, et al. Exposure assessment using human biomonitoring for glyphosate and fluroxypyr users in amenity horticulture. Int J Hyg Environ Health. 2017 Aug 1;220(6):1064–73
95. Biomonitoring Summary CDC https://www.cdc.gov/biomonitoring
96. Chlorpyrifos Technical Fact Sheet: http://npic.orst.edu/factsheets/archive
97. Motsoeneng PM, Dalvie MA. Relationship between urinary pesticide residue levels and neurotoxic symptoms among women on farms in the Western Cape, South Africa. Int J Environ Res Public Health. 2015 Jun 2;12(6):6281–99
98. Wang L, Liu Z, Zhang J, Wu Y, Sun H. Chlorpyrifos exposure in farmers and urban adults: Metabolic characteristic, exposure estimation, and potential effect of oxidative damage. Environ Res. 2016 Aug 1;149:164–70
99. Phung DT, Connell D, Miller G, Hodge M, Patel R, Cheng R, et al. Biological monitoring of chlorpyrifos exposure to rice farmers in Vietnam. Chemosphere. 2012 Apr;87(4):294–300
100. Khan K, Ismail AA, Abdel Rasoul G, Bonner MR, Lasarev MR, Hendy O, et

al. Longitudinal assessment of chlorpyrifos exposure and self-reported neurological symptoms in adolescent pesticide applicators. BMJ Open. 201;4(3):12-8
101. Farahat FM, Ellison CA, Bonner MR, Mcgarrigle BP, Crane AL, Fenske RA, et al. Biomarkers of chlorpyrifos exposure and effect in Egyptian cotton field workers. Environ Health Perspect. 2011 Jun;119(6):801–6
102. Dowling KC, Blanco R. LE, Martinez M. I, Aragon B. A, Bernard CE, Krieger RI. Urinary 3,5,6-trichloro-2-pyridinol levels of chlorpyrifos in nicaraguan applicators and small farm families. Bull Environ Contam Toxicol. 2005 Feb;74(2):380–7
103. Morgan M, Jones P, Sobus J, Barr DB. Predictors of urinary 3-phenoxybenzoic acid levels in 50 North Carolina adults. Int J Environ Res Public Health. 2016 Nov 23;13(11):165-71
104. Thiphom S, Prapamontol T, Chantara S, Mangklabruks A, Suphavilai C, Ahn KC, et al. Determination of the pyrethroid insecticide metabolite 3-PBA in plasma and urine samples from farmer and consumer groups in northern Thailand. J Environ Sci Heal - Part B Pestic Food Contam Agric Wastes. 2014 Jan;49(1):15–22
105. Chrustek A, Hołynska-Iwan I, Dziembowska I, Bogusiewicz J, Wroblewski M, Cwynar A, et al. Current research on the safety of pyrethroids used as insecticides. Medicina (Lithuania). 2018;54(2):145-51
106. Hongsibsong S, Prapamontol T, Dong JX, Bever CS, Xu ZL, Gee SJ, et al. Exposure of consumers and farmers to organophosphate and synthetic pyrethroid insecticides in Northern Thailand. J fur Verbraucherschutz und Leb . 2019 Mar 4;14(1):17–23
107. Hughes EA, Flores AP, Ramos LM, Zalts A, Richard Glass C, Montserrat JM. Potential dermal exposure to deltamethrin and risk assessment for manual sprayers: Influence of crop type. Sci Total Environ. 2008 Feb 25;391(1):34–40
108. Da Silva M, Stadlinger N, Mmochi AJ, Stalsby Lundborg C, Marrone G. Pesticide Use and Self-Reported Health Symptoms Among Rice Farmers in Zanzibar. J Agromedicine . 2016 Oct 20;21(4):335–44
109. Jensen HK, Konradsen F, Jors E, Petersen JH, Dalsgaard A. Pesticide use and self-reported symptoms of acute pesticide poisoning among aquatic farmers in phnom penh, cambodia. J Toxicol. 2011;2011:23-7
110. Li J, Dong L, Tian D, Zhao Y, Yang H, Zhi X, et al. Association between pesticide exposure intensity and self-rated health among greenhouse vegetable farmers in Ningxia, China. PLoS One. 2018 Dec 21;13(12):55-9
111. Memon QUA, Wagan SA, Chunyu D, Shuangxi X, Jingdong L, Damalas CA. Health problems from pesticide exposure and personal protective measures among women cotton workers in southern Pakistan. Sci Total Environ. 2019 Oct 1;685:659–66
112. Bolarinwa O. Principles and methods of validity and reliability testing of questionnaires used in social and health science researches. Niger Postgrad Med J. 2015;22(4):195-98
113. Dosemeci M, Alavanja M, Rowland, Mage D, Zahm S. A Quantitative Approach for Estimating Exposure to Pesticides in the Agricultural Health

Study. Ann Occup Hyg. 2002 Mar;46(2):245-60
114. Coble J, Arbuckle T, Lee W, Alavanja M, Dosemeci M. The validation of a pesticide exposure algorithm using biological monitoring results. J Occup Environ Hyg. 2005 Mar;2(3):194–201
115. Acquavella JF, Alexander BH, Mandel JS, Burns CJ, Gustin C. Exposure misclassification in studies of agricultural pesticides: Insights from biomonitoring. Epidemiology. 2006 Jan;17(1):69–74
116. Hines CJ, Deddens JA, Jaycox LB, Andrews RN, Striley CAF, Alavanja MCR. Captan exposure and evaluation of a pesticide exposure algorithm among orchard pesticide applicators in the agricultural health study. Ann Occup Hy. 2008 Apr;52(3):153–66
117. Negatu B, Vermeulen R, Mekonnen Y, Kromhout H. A Method for Semi-quantitative Assessment of Exposure to Pesticides of Applicators and Re-entry Workers: An Application in Three Farming Systems in Ethiopia. Ann Occup Hy. 2016 Jul;60(6):669–83
118. Garrod ANI, Rajan-Sithamparanadarajah R. Developing COSHH Essentials: Dermal Exposure, Personal Protective Equipment and First Aid. Ann occup Hyg. 2003;47(7):577–88
119. LE, Blanco LE, Aragon A, Lundberg I, Wesseling. The Determinants of Dermal Exposure Ranking Method (DERM): A Pesticide Exposure Assessment Approach for Developing Countries. Ann Occup Hyg. 2008 Aug;52(6):535-44
120. Van-Wendel-de-Joode B, Brouwer DH, Vermeulen R, Van Hemmen JJ, Heederik D, Kromhout H. DREAM: a method for semi-quantitative dermal exposure assessment. Ann Occup Hy. 2003 Jan ;47(1):71–8
121. Tickner J, Friar J, Creely KS, Cherrie JW, Pryde DE, Kingston J. The development of the EASE model. Ann Occup Hyg. 2005 Mar;49(2):103–10
122. Van Wendel De Joode B, Vermeulen R, Van Hemmen JJ, Fransman W, Kromhout H. Accuracy of a semiquantitative method for Dermal Exposure Assessment (DREAM). Occup Env Med. 2005;62:623–32
123. Fabian CL, Binder CR. Dermal exposure assessment to pesticides in farming systems in developing countries: Comparison of models. Int J Environ Res Public Health. 2015 Apr 29;12(5):4670–96
124. Tadevosyan A, Tadevosyan N, Kelly K, Gibbs SG, Rautiainen RH. Pesticide Use Practices in Rural Armenia. J Agromedicine . 2013 Oct 2;18(4):326–33
125. Kamaruzaman NA, Leong Y-H, Jaafar MH, Rahman H, Khan M, Afiza N, et al. Epidemiology and risk factors of pesticide poisoning in Malaysia: A retrospective analysis by the National Poison Centre (NPC) from 2006 to 2015. BMJ Open. 2020;23(2):22-27
126. Thundiyil JG. Policy and practice Acute pesticide poisoning. Bull World Health Organ. 2008;86(3):112-15
127. Pesticides - Health Effects : OSH Answers.: https://www.ccohs.ca/oshanswers
128. Nicolopoulou-Stamati P, Maipas S, Kotampasi C, Stamatis P, Hens L. Chemical Pesticides and Human Health: The Urgent Need for a New Concept in Agriculture. Front Public Health. 2016;4:148-52
129. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses:The PRISMA statement. BMJ Publishing

Journal. 2009;339:332-6
130. Herzog R, Alvarez-Pasquin MJ, Díaz C, Del Barrio JL, Estrada JM, Gil A. Are healthcare workers intentions to vaccinate related to their knowledge, beliefs and attitudes-A systematic review. BMC Public Health. 2013;13:(154)
131. Khan S, Ibrahim Y, Saffree Jeffree M. Evaluating Perception of Farmers towards the Health Effect of Pesticides: A Cross- Sectional Study in the Oil Palm Plantations of Papar, Malaysia. J Plant Physiol Pathol. 2019 Feb 18;07(01):15-25
132. Ali J, Yusof N, Abd. Aziz FS. Factors influencing farmer's perceptions and behaviour toward pesticide use in Malaysia. Int J Soc Econ. 2018 May 14;45(5):776–92
133. Hamid ZA, Zulkifly MFM, Hamid A, Lubis SH, Mohammad N, Ishak I, et al. The association of nuclear abnormalities in exfoliated buccal epithelial cells with the health status of different agricultural activities farmers in Peninsular Malaysia. Genes Environ. 2016;38(1):1-9
134. Gayatri K, Govinda D. Pesticide Poisoning Among Commercial Vegetable Farmers of Chitwan, Nepal. 2016;6:19–25
135. Sumon KA, Rico A, Ter Horst MMS, Van den Brink PJ, Haque MM, Rashid H. Risk assessment of pesticides used in rice-prawn concurrent systems in Bangladesh. Sci Total Environ. 2016 Oct 15;568:498–506
136. Zhang X, Zhao W, Jing R, Wheeler K, Smith GA, Stallones L, et al. Work-related pesticide poisoning among farmers in two villages of Southern China: A cross-sectional survey. BMC Public Health 2011;11:429-37
137. Butinof M, Fernandez RA, Stimolo MI, Lantieri MJ, Blanco M, Machado AL, et al. Exposição aos agrotóxicos e condiçoes de saude dos aplicadores de pesticidas da Província de Córdoba, Argentina. Cad Saude Publica. 2015;31(3):633–46
138. Hutter HP, Kundi M, Lemmerer K, Poteser M, Weitensfelder L, Wallner P, et al. Subjective symptoms of male workers linked to occupational pesticide exposure on coffee plantations in the Jarabacoa region, dominican republic. Int J Environ Res Public Health. 2018 Sep 25;15(10):112-17
139. Mwabulambo SG, Mrema EJ, Vera Ngowi A, Mamuya S. Health symptoms associated with pesticides exposure among flower and onion pesticide applicators in Arusha region. Ann Glob Heal. 2018;84(3):369–79
140. Zyoud SH, Sawalha AF, Sweileh WM, Awang R, Al-Khalil SI, Al-Jabi SW, et al. Knowledge and practices of pesticide use among farm workers in the West Bank, Palestine: safety implications. Environ Health Prev Med. 2010 ;15(4):252–61
141. Ranau (District, Malaysia) - Population Statistics, Charts, Map and Location. https://www.citypopulation.de/en/malaysia/admin/sabah/1208__ranau/
142. Bachok (District, Malaysia) - Population Statistics, Charts, Map and Location. https://www.citypopulation.de/en/malaysia/admin/kelantan/0301__bachok/
143. Department of Statistics Malaysia Official Portal https://www.dosm.gov.my/v1
144. Cherry N, Mackness M, Durrington P, Povey A, Dippnall M, Smith T, et al. Paraoxonase (PON1) polymorphisms in farmers attributing ill health to sheep dip. Lancet (London, England). 2002 Mar 2;359(9308):763–4

145. Povey AC, Rees HG, Thompson JP, Watkins G, Stocks SJ, Karalliedde L. Acute ill-health in sheep farmers following use of pesticides. Occup Med (Chic Ill). 2012 Oct;62(7):541–8
146. Povey AC, McNamee R, Alhamwi H, Stocks SJ, Watkins G, Burns A, et al. Pesticide exposure and screen-positive neuropsychiatric disease in British sheep farmers. Environ Res. 2014 Nov;135:262–70
147. Galea KS, MacCalman L, Jones K, Cocker J, Teedon P, Sleeuwenhoek AJ, et al. Biological monitoring of pesticide exposures in residents living near agricultural land. BMC Public Health. 2011 Dec 10;11(1):856-63
148. The German External Quality Assessment Scheme For Analyses in Biological Materials: http://www.g-equas.de
149. Sams C, Jones K. Human volunteer studies investigating the potential for toxicokinetic interactions between the pesticides deltamethrin; Pirimicarb and chlorpyrifos-methyl following oral exposure at the acceptable daily intake. Toxicol Lett. 2011 Jan 15;200(1–2):41–5
150. Cocker J, Mason HJ, Warren ND, Cotton RJ. Creatinine adjustment of biological monitoring results. Occup Med (Chic Ill). 2011;61:349–53
151. Ratner B. The correlation coefficient: Its values range between +1/−1, or do they J Targeting, Meas Anal Mark. 2009 Jun 18;17(2):139–42
152. Koo TK, Li MY. A Guideline of Selecting and Reporting Intraclass Correlation Coefficients for Reliability Research. J Chiropr Med . 2016 Jun 1;15(2):155–63
153. Rastogi P, Singh BK. A Multivariate Binary Logistic Regression Modeling for Assessing Various Risk Factors that affect Diabetes. Int J Sci Technol Res. 2019;8:8-15
154. Li Y, Zhang C, Yin Y, Cui F, Cai J, Chen Z, et al. Neurological effects of pesticide use among farmers in China. Int J Environ Res Public Health. 2014 Apr 14;11(4):3995–4006
155. Nishida C, Barba C, Cavalli-Sforza T, Cutter J, Deurenberg P, Darnton-Hill I, et al. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004 Jan 10;363(9403):157–63
156. Income for Malaysia population.2010.Eomomy Planning Unit, Malaysia Prime Minister’s Department: https://www.epu.gov.my/en/socio-economic-statistics
157. Said AH, Chia YC. Awareness, knowledge and practice of dyslipidaemia management among postgraduate primary care trainees in Malaysia: A cross-sectional study. BMJ Open. 2017 Mar 1;7(3):15-23
158. Kroenke K, Spitzer RL, Williams JBW. The PHQ-15: Validity of a new measure for evaluating the severity of somatic symptoms. Psychosom Med. 2002;64(2):258–66
159. Chan DKY, Hung WT, Wong A, Hu E, Beran RG. Validating a screening questionnaire for parkinsonism in Australia. J Neurol Neurosurg Psychiatry. 2000;69(1):117–20
160. Spitzer RL, Kroenke K, Williams JBW. Validation and utility of a self-report version of PRIME-MD: The PHQ Primary Care Study. J Am Med Assoc. 1999 Nov 10;282(18):1737–44
161. Moen P, Chermack K. Lay Person-Based Screening for Early Detection of Alzheimer’s Disease: Development and Validation of an Instrument. J Gerontol

B Psychol Sci Soc Sci. 2000;55(Special_Issue_3):163-74
162. Maroni M, Fanetti AC, Metruccio F. Risk assessment and management of occupational exposure to pesticides in agriculture. Med Lav ;97(2):430–7
163. Mancini F, Van Bruggen AHC, Jiggins JLS, Ambatipudi AC, Murphy H. Acute Pesticide Poisoning among Female and Male Cotton Growers in India. Int J Occup Environ Health. 2005 Jul;11(3):221–32
164. Jors E, Morant RC, Aguilar GC, Huici O, Lander F, Baelum J, et al. Occupational pesticide intoxications among farmers in Bolivia: A cross-sectional study. Environ Heal A Glob Access Sci Source. 2006 Apr 21;5:11-7
165. Cornwall J, Ford M, Liyanage T, Daw Dwk. Risk assessment and health effects of pesticides used in tobacco farming in Malaysia. Health Policy Plan. 1995 Dec 1;10(4):431–7
166. WHO Cataloguing in Publication Data 2005: http://www.who.int/ipcs/publications
167. Jors E, Gonzales AR, Ascarrunz ME, Tirado N, Takahashi C, Lafuente E, et al. Genetic Alterations in Pesticide Exposed Bolivian Farmers: An evaluation by analysis of chromosomal aberrations and the comet assay. Biomark Insights. 2007 Nov 12;2:439–45
168. Dasgupta S, Meisner C, Wheeler D, Xuyen K, Thi Lam N. Pesticide poisoning of farm workers–implications of blood test results from Vietnam. Int J Hyg Environ Health. 2007 Mar 7;210(2):121–32
169. Kimani VN, Mwanthi MA. Agrochemicals exposure and health implications in Githunguri location, Kenya. East Afr Med J. 1995 Aug;72(8):531–5
170. Matthews G, Wiles T, Baleguel P. A survey of pesticide application in Cameroon. Crop Prot. 2003 Jun 1;22(5):707–14
171. Willemse BWM, Postma DS, Timens W, Ten Hacken NHT. The impact of smoking cessation on respiratory symptoms, lung function, airway hyperresponsiveness and inflammation. Eur Respir J. 2004 Mar;23(3):464-76
172. Mathew P, Jose A, Alex R, Mohan V. Chronic pesticide exposure: Health effects among pesticide sprayers in Southern India. Indian J Occup Environ Med. 2015 May 1;19(2):95–101
173. Global Herbicide Classification Lookup | Herbicide Resistance Action Committee: https://hracglobal.com/tools/classification-lookup
174. Insecticide Resistance Action Committee | IRAC [Internet].: https://irac-online.org/
175. Panuwet P, Prapamontol T, Chantara S, Thavornyuthikarn P, Montesano MA, Whitehead RD, et al. Concentrations of urinary pesticide metabolites in small-scale farmers in Chiang Mai Province, Thailand. Sci Total Environ. 2008 Dec 15;407(1):655–68
176. Cerruto E, Manetto G, Santoro F, Pascuzzi S. Operator Dermal Exposure to Pesticides in Tomato and Strawberry Greenhouses from Hand-Held Sprayers. Sustainability. 2018 Jul 2;10(7):2273-84
177. Fuhrimann S, Staudacher P, Lindh C, Van Wendel De Joode B, Mora AM, Winkler MS, et al. Variability and predictors of weekly pesticide exposure in applicators from organic, sustainable and conventional smallholder farms in Costa Rica. Occup Environ Med. 2020 Jan 1;77(1):40–7

178. Suratman S, Edwards JW, Babina K. Organophosphate pesticides exposure among farmworkers: pathways and risk of adverse health effects. Rev Environ Health. 2015;30(1):65–79
179. Ab Halim N ADR. Transformation of Vegetable Industry through Policy Intervention and Technology Transfer: https://ap.fftc.org.tw/article
180. Chandio AA, Jiang Y, Gessesse AT, Dunya R. The Nexus of Agricultural Credit, Farm Size and Technical Efficiency in Sindh, Pakistan: A Stochastic Production Frontier Approach. J Saudi Soc Agric Sci. 2019 Jul 1;18(3):348–54
181. Landgren CG, Cooper A, Ketchum L. Calibrating and using backpack sprayers. 1996;(April):1–20
182. Ogunjimi SI, Farinde AJ. Farmers' Knowledge Level of Precautionary Measures in Agro-Chemicals Usage on Cocoa Production in Osun and Edo States, Nigeria. Int J Agric For. 2012 Aug 31;2(4):186–94
183. Eddleston M, Karalliedde L, Buckley N, Fernando R, Hutchinson G, Isbister G, et al. Pesticide poisoning in the developing world—A minimum pesticides list. Lancet. 2002 Oct 12;360(9340):1163–7
184. Jallow M, Awadh D, Albaho M, Devi V, Thomas B. Pesticide Knowledge and Safety Practices among Farm Workers in Kuwait: Results of a Survey. Int J Environ Res Public Health. 2017 Mar 24;14(4):340-8
185. Selvarajah A, Thiruchelvam S. Factors Affecting Pesticide Use by Farmers in Vavuniya District. Trop Agri Res. 2007:19:380-8
186. Khan M, Mahmood HZ, Damalas CA. Pesticide use and risk perceptions among farmers in the cotton belt of Punjab, Pakistan. Crop Prot. 2015 Jan 1;67:184–90
187. Serrano-Medina A, Ugalde-Lizarraga A, Bojorquez-Cuevas MS, Garnica-Ruiz J, Gonzalez-Corral MA, García-Ledezma A, et al. Neuropsychiatric Disorders in Farmers Associated with Organophosphorus Pesticide Exposure in a Rural Village of Northwest Mexico. Int J Environ Res Public Health. 2019;16(5):73-9
188. Ahmad MI, Ahmad NA, Muhammad A, Esa N. A Survey on Use, Hazards and Potential Risks of Rice Farming Pesticides in Permatang Keriang, Pulau Pinang (Malaysia). Int J Sci Res Publ. 2014;4(10):1-9
189. Derafshi M, Black C, Agnew R. Pesticide Knowledge, Attitudes, and Clothing Practices of Turkish Farmers. Environ Manag Sustain De. 2017 Mar 31;6(1):149-53
190. Abhilash PC, Singh N. Pesticide use and application: An Indian scenario. J Hazard Mater. 2009 Jun 15;165(1–3):1–12
191. Hoi P V., Mol APJ, Oosterveer P, van den Brink PJ, Huong PTM. Pesticide use in Vietnamese vegetable production: a 10-year study. Int J Agric Sustain. 2016 Jul 2;14(3):325–38
192. Joko T, Anggoro S, Sunoko HR, Rachmawati S. Pesticides Usage in the Soil Quality Degradation Potential in Wanasari Subdistrict, Brebes, Indonesia. Appl Environ Soil Sci. 2017 Jul 3;2017:1–7
193. Yuantari MGC, Van Gestel CAM, Van Straalen NM, Widianarko B, Sunoko HR, Shobib MN. Knowledge, attitude, and practice of Indonesian farmers regarding the use of personal protective equipment against pesticide exposure. Environ Monit Assess. 2015 Mar 26 ;187(3):142-49

194. Peiris-John RJ, Ruberu DK, Wickremasinghe AR, van-der-Hoek W. Low-level exposure to organophosphate pesticides leads to restrictive lung dysfunction. Respir Med. 2005 Oct 1;99(10):1319–24
195. Andrade-Rivas F, Rother H-A. Chemical exposure reduction: Factors impacting on South African herbicide sprayers' personal protective equipment compliance and high risk work practices. Environ Res. 2015 Oct 1;142:34–45
196. Lawal BO, Torimiro DO, Banjo AD, Joda AO. Operational Habits and Health Hazards Associated With Pesticide Usage by Cocoa Farmers in Nigeria: Lessons for Extension Work. J. Hum. Ecol. 2005;17(3):121-29
197. Mohanty MK, Behera BK, Jena SK, Srikanth S, Mogane C, Samal S, et al. Knowledge attitude and practice of pesticide use among agricultural workers in Puducherry, South India. J Forensic Leg Med. 2013 Nov 1;20(8):1028–31
198. Bin Nordin R, Araki S, Sato H, Yokoyama K, Abdul W, Bin M, et al. Effects of Safety Behaviours with Pesticide Use on Occurrence of Acute Symptoms in Male and Female Tobacco-growing Malaysian Farmers. Ind Health. 2002 Apr;40(2):182-90
199. Gupta A. Pesticide use in South and South-East Asia: Environmental Public Health and Legal Concerns. Am. J. Environ. Sci 8. 2012 (2): 152-157
200. Ndayambaje B, Amuguni H, Coffin-Schmitt J, Sibo N, Ntawubizi M, Vanwormer E. Pesticide application practices and knowledge among small-scale local rice growers and communities in rwanda: A cross-sectional study. Int J Environ Res Public Health. 2019 Dec 1;16(23):1-7
201. Samsuddin N, Rampal KG, Ismail NH, Abdullah NZ, Nasreen HE. Pesticide Exposure and Cardiovascular Hemodynamic Parameters Among Male Workers Involved in Mosquito Control in East Coast of Malaysia. Am J Hypertens. 2016 Feb;29(2):226–33
202. Ranjbar M, Rotondi MA, Ardern CI, Kuk JL. The influence of urinary concentrations of organophosphate metabolites on the relationship between BMI and cardiometabolic health risk. J Obes. 2015;3(2):23-32
203. Grandjean P, Harari R, Barr DB, Debes F. Pesticide exposure and stunting as independent predictors of neurobehavioral deficits in Ecuadorian school children. Pediatrics. 2006 Mar;117(3):43-49
204. Cypel YS, Kress AM, Eber SM, Schneiderman AI, Davey VJ. Herbicide exposure, Vietnam service, and hypertension risk in army chemical corps veterans. J Occup Environ Med. 2016 Nov 28;58(11):1127–36
205. Van Maele-Fabry G, Hoet P, Vilain F, Lison D. Occupational exposure to pesticides and Parkinson's disease: A systematic review and meta-analysis of cohort study. Environ Int. 2012 Oct 1;46:30-43
206. Freire C, Koifman S. Pesticides, depression and suicide: A systematic review of the epidemiological evidence. Int J Hyg Environ Health. 2013;216(1): 445–60
207. Yan D, Zhang Y, Liu L, Yan H. Pesticide exposure and risk of Alzheimer's disease: A systematic review and meta-analysis. Sci Rep. 2016 Sep 1;6:1-8
208. Department of Statistics Malaysia press release statistics on causes of death, Malaysia, 2018. https://www.dosm.gov.my
209. Ab Majid NL, Omar MA, Khoo YY, Mahadir Naidu B, Ling Miaw Yn J, Rodzlan Hasani WS, et al. Prevalence, Awareness, Treatment and Control of

hypertension in the Malaysian population: findings from the National Health and Morbidity Survey 2006–2015. J Hum Hypertens. 2018 Sep 1;32(8–9):617–24

210. Attfield KR, Hughes MD, Spengler JD, Lu C. Within- and between-child variation in repeated urinary pesticide metabolite measurements over a 1-year period. Environ Health Perspect. 2014 Feb;122(2):201–6

211. Barr DB, Thomas K, Curwin B, Landsittel D, Raymer J, Lu C, et al. Biomonitoring of exposure in farmworker studies. Environ Health Perspect. 2006 Jun;114(6):936–42

212. Udin NM, Norkhadijah S, Ismail S, How V, Abidin EZ. Dermal Exposure to Pesticides among Sprayers in Different Agriculture Subsectors in Malaysia: Observational Method using DREAM. Malays. J. Med. Health Sci.2019;15(02):152-55

213. Agostini M, Fransman W, Vocht F De, Joode BVW De, Kromhout H. Assessment of dermal exposure to bitumen condensate among road paving and mastic crews with an observational method. Ann Occup Hyg. 2011 Jul;55(6):578–90

214. Van Wendel de Joode B, van Hemmen JJ, Meijster T, Major V, London L, Kromhout H. Reliability of a semi-quantitative method for dermal exposure assessment (DREAM). J Expo Anal Environ Epidemiol. 2005 Jan;15(1):111-20

215. Jager KJ, Tripepi G, Chesnaye NC, Dekker FW, Zoccali C, Stel VS. Where to look for the most frequent biases? Nephrology (Carlton). 2020 Jun;25(6):435-44

216. Satya Sai MV, Revati GD, Ramya R, Swaroop A, Maheswari E, Kumar M. Knowledge and perception of farmers regarding pesticide usage in a rural farming village, Southern India. Indian J Occup Environ Med. 2019 Jan 1 ;23(1):32–6

217. Kamsia B, Shahida, Celestina, Suriani A, Norlita, Khadizah G. Knowledge, Attitude and Practice of Pesticide Use among Oil Palm Smallholders in Sandakan, Sabah. J. Agric. Vet. 2014;2(2):18-20

218. Marina Mior SN, Leman AM, Baharudin MR, Masripan R, Faazir T. M, Ifwat A. M. A Preliminary Study of Knowledge, Attitude and Practices of Pesticide Use Among Oil Palm Workers in Johor. IConGDM. 2016;78(1-7)

219. Mubushar M, Aldosari FO, Baig MB, Alotaibi BM, Khan AQ. Assessment of farmers on their knowledge regarding pesticide usage and biosafety. Saudi J Biol Sci. 2019 Mar 6;3(1):1343-49

220. Ricco M, Vezzosi L, Gualerzi G. Health and safety of pesticide applicators in a high income agricultural setting: a knowledge, attitude, practice, and toxicity study from North-Eastern Italy. J Prev Med Hyg. 2018 Sep ;59(3):200–11

221. Okoffo ED, Mensah M, Fosu-Mensah BY. Pesticides exposure and the use of personal protective equipment by cocoa farmers in Ghana. Environ Syst Res. 2016 Dec 27;5(1):17-23

222. Damalas CA, Abdollahzadeh G. Farmers' use of personal protective equipment during handling of plant protection products. Sci Total Environ. 2016 Nov 15;571:730-6

223. Kearney GD, Xu X, Balanay JAG, Allen DL, Rafferty AP. Assessment of

Personal Protective Equipment Use Among Farmers in Eastern North Carolina: A Cross-sectional Study. J Agromedicine. 2015 Jan 2 ;20(1):43–54
224. Feola G, Binder CR. Why Don't Pesticide Applicators Protect Themselves?. Int J Occup Environ Health. 2010 Jan;16(1):11–23
225. Abang AF, Kouame CM, Abang M, Hanna R, Fotso AK. Assessing Vegetable Farmer Knowledge of Diseases and Insect Pests of Vegetable and Management Practices Under Tropical Conditions. Int J Veg Sci. 2014 Jul 3;20(3):240–53
226. Rostami F, Afshari M, Rostami-Moez M, Assari M, Soltanian A. Knowledge, attitude,
and practice of pesticides use among agricultural workers. Indian J Occup Environ
Med. 2019 Jan 1;23(1):42–7
227. Make sure products are compatible when tank mixing spray partners - MSU Extension Michigan State University. https://www.canr.msu.edu/news
228. Kim JH, Kim J, Cha ES, Ko Y, Kim DH, Lee WJ. Work-related risk factors by severity for acute pesticide poisoning among male farmers in South Korea. Int J Environ Res Public Health. 2013;10(3):1100–12
229. Pesticide Storage, Handling and Disposal | UMass Center for Agriculture, Food and the Environment; https://ag.umass.edu/greenhouse-floriculture
230. Ishak I. Program Kesihatan Ke Arah Petani Sihat dan Productive. In: Unpublished paper. 2014.
231. Amekawa Y, Chuan NC, Lumayag LA, Tan GH, Wong CS, Abdulra`uf LB, et al. Producers` perceptions of public good agricultural practices and their pesticide use: The case of MyGAP for durian farming in Pahang, Malaysia. Asian J Agric Rural Dev. 2017 Jan;7(1):1–16
232. Raimi MO. Self-Reported Symptoms on Farmers Health and Commonly Used Pesticides Related to Exposure in Kura, Kano State, Nigeria.Public Health Remedy Publications LLC.2021 Jan;1(2):22-5
233. Etikan I, Musa SA, Alkassim RS. Comparison of Convenience Sampling and Purposive Sampling. Am J Theor Appl Stat. 2016 Dec 22;5(1):1-9
234. Hanchenlaksh C, Povey A, de Vocht F. Exposure to organophosphate pesticides in Thai farmers and their families. Occup Environ Med. 2011 Sep 1;68(Suppl_1):A107
235. Button KS, Ioannidis JPA, Mokrysz C, Nosek BA, Flint J, Robinson ESJ, et al. Power failure: why small sample size undermines the reliability of neuroscience. Nat Rev Neurosci. 2013 Apr 10;14(5):365–76
236. Hamsan H, Ho Y Bin, Zaidon SZ, Hashim Z, Saari N, Karami A. Occurrence of commonly used pesticides in personal air samples and their associated health risk among paddy farmers. Sci Total Environ. 2017 Dec 15 ;603–604:381–9
237. Schreinemachers P, Balasubramaniam S, Boopathi NM, Ha CV, Kenyon L, Praneetvatakul S, et al. Farmers' perceptions and management of plant viruses in vegetables and legumes in tropical and subtropical Asia. Crop Prot. 2015 Sep ;75:115–23
238. Damalas CA, Koutroubas SD. Farmers' Training on Pesticide Use Is Associated with Elevated Safety Behavior. Toxics 2017 Aug 22;5(3):196-99

APPENDICES

Appendix 1: Research Ethics Approval for Pilot Study (Malaysia)

JAWATANKUASA ETIKA & PENYELIDIKAN PERUBATAN
(Medical Research & Ethics Committee)
KEMENTERIAN KESIHATAN MALAYSIA
d/a Institut Pengurusan Kesihatan
Jalan Rumah Sakit, Bangsar
59000 Kuala Lumpur

Tel.: 03-2287 4032/2282 0491/2282 9085
03-2282 9082/2282 1402/2282 1449
Faks: 03-2282 0015

Ruj.Kami :(ll)KKM/NIHSEC/ P17-848
Tarikh : **03-Ogos-2017**

DR ZULKHAIRUL NAIM BIN SIDEK AHMAD
UNIVERSITY OF MANCHESTER

Dato'/ Dr/ Tuan/ Puan,

SURAT KELULUSAN ETIKA:

NMRR-17-424-34635 (IIR)
NO. PROTOKOL : N/A
ORGANOPHOSPHATE EXPOSURE AND GENERAL AND REPRODUCTIVE HEALTH AMONG FARMERS IN SABAH; A LONGITUDINAL STUDY

Dengan hormatnya perkara di atas adalah dirujuk.

2. Bersama dengan surat ini dilampirkan surat kelulusan saintifik dan etika bagi projek ini. Segala rekod dan data subjek adalah SULIT dan hanya digunakan untuk tujuan kajian dan semua isu serta prosedur mengenai *data confidentiality* mesti dipatuhi. Kebenaran daripada Pengarah Hospital / Institusi di mana kajian akan dijalankan mesti diperolehi terlebih dahulu sebelum kajian dijalankan. Dato'/ Tuan/ Puan perlu akur dan mematuhi keputusan tersebut.

3. Penyelidik- penyelidik yang terlibat ialah:

   Hospital Kota Marudu
   Dr Zulkhairul Naim Bin Sidek Ahmad (Penyelidik Utama)

   Hospital Pitas
   Dr Zulkhairul Naim Bin Sidek Ahmad (Penyelidik Utama)

   Hospital Ranau
   Dr Zulkhairul Naim Bin Sidek Ahmad (Penyelidik Utama)

   Jabatan Kesihatan Negeri Sabah
   Dr Zulkhairul Naim Bin Sidek Ahmad (Penyelidik Utama)

4. Adalah dimaklumkan bahawa kelulusan ini adalah sah sehingga **02-Ogos-2018**. Tuan/Puan perlu menghantar dokumen-dokumen seperti berikut selepas mendapat kelulusan etika. Borang-borang berkaitan boleh dimuat turun daripada laman web Jawatakuasa Etika & Penyelidikan Perubatan (JEPP) (http://www.nih.gov.my/mrec).

   i. ***Continuing Review Form*** selewat-lewatnya dalam tempoh 1 bulan (30 hari) sebelum tamat tempoh kelulusan ini bagi memperbaharui kelulusan etika.
   ii. ***Study Final Report*** pada penghujung kajian.
   iii. Mendapat kelulusan etika sekiranya terdapat pindaan ke atas sebarang dokumen kajian/ lokasi kajian/ penyelidik.

iv. Kajian berkenaan intervensi klinikal sahaja: Laporan mengenai ***all Serious Adverse Events (SAEs), Suspected Unexpected Serious Adverse Reaction (SUSARs)*** dan ***Protocol Deviation/Violation*** di lokasi kajian yang diluluskan oleh JEPP jika berkenaan. *SAE* perlu dilaporkan dalam tempoh 15 hari kalender dari kesedaran kejadian (*awareness of event)* oleh penyelidik. Laporan awal *SUSAR* perlu dikemukakan seawal mungkin tapi tidak melewati 7 hari calendar dari kesedaran kejadian oleh penyelidik, disusuli dengan laporan lengkap dalam tempoh tambahan 8 hari kalender.

5. Bilangan subjek/ pesakit/ responden yang disasarkan untuk menyertai kajian ini di Malaysia adalah **150 orang**.

6. Sila ambil maklum bahawa sebarang urusan surat-menyurat berkaitan dengan penyelidikan ini haruslah dinyatakan nombor rujukan surat ini untuk melicinkan urusan yang berkaitan.

Sekian terima kasih.

"BERKHIDMAT UNTUK NEGARA"

Saya yang menurut perintah,

....

DATO' DR CHANG KIAN MENG
Pengerusi
Jawatankuasa Etika & Penyelidikan Perubatan
Kementerian Kesihatan Malaysia

s.k:

HRRC Hospital Queen Elizabeth I, Sabah

Appendix 2: Research Ethics Approval for Pilot Study (The University of Manchester)

Research Governance, Ethics and Integrity
2nd Floor Christie Building
The University of Manchester
Oxford Road
Manchester
M13 9PL
Tel: 0161 275 2206/2674
Email: research.ethics@manchester.ac.uk

Ref: 2017-0439-4327

07/02/2018

Dear Mr Zulkhairul Naim Sidek Ahmad, , Dr Andrew Povey

Study Title: Organophosphate exposure and general and reproductive health

University Research Ethics Committee 1

I write to thank you for submitting the final version of your documents for your project to the Committee on 20/11/2017 16:05 . I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form and supporting documentation as submitted and approved by the Committee.

Please see below for a table of the title, version numbers and dates of all the final approved documents for your project:

Document Type	File Name	Date	Version
Questionnaire	screening questionnaire	21/09/2017	1
Questionnaire	hospitalvisitquestionnaire	21/09/2017	1
Questionnaire	diary	21/09/2017	1
Additional docs	ethical approval	21/09/2017	1
Additional docs	document translation	21/09/2017	1
Questionnaire	interviewquestionnaire	21/09/2017	1
Questionnaire	DREAM	21/09/2017	1
Consent Form	CONSENT FORM FOR FARMERS	21/09/2017	1
Lone Worker Policy/Procedure	Lone working procedure	21/09/2017	1
Additional docs	intoductory letter	21/09/2017	1
Additional docs	Sample Telephone Script	21/09/2017	1
Participant Information Sheet	Participant Information SheetV2	20/11/2017	2
Lone Worker Policy/Procedure	Lone working procedureV2	20/11/2017	2
Additional docs	UREC REVISION-20-11-2017	20/11/2017	1

This approval is effective for a period of five years however please note that it is only valid for the specifications of the research project as outlined in the approved documentation set. If the project continues beyond the 5 year period or if you wish to propose any changes to the methodology or any other specifics within the project, an application to seek an amendment must be submitted for review. Failure to do so could invalidate the insurance and constitute research misconduct.

You are reminded that, in accordance with University policy, any data carrying personal identifiers must be encrypted when not held on a secure university computer or kept securely as a hard copy in a location which is accessible only to those involved with the research.

Reporting Requirements:

You are required to report to us the following:

1. Amendments
2. Breaches and adverse events
3. Notification of progress/end of the study

Feedback

It is our aim to provide a timely and efficient service that ensures transparent, professional and proportionate ethical review of research with consistent outcomes, which is supported by clear, accessible guidance and training for applicants and committees. In order to assist us with our aim, we would be grateful if you would give your view of the service that you have received from us by completing a **UREC Feedback Form**. Instructions for completing this can be found in your approval email.

We wish you every success with the research.

Yours sincerely,

Appendix 3: Research Ethics Amendment Approval for Main Study (The University of Manchester)

Reply | Reply All | Forward | Junk | Close

APPROVED: UREC Amendment Ref: 2018-0439-6695 (Automatic Email from the UoM Ethical Review Manager (ERM) system)

donotreply@infonetica.net [donotreply@infonetica.net]

Sent: 16 July 2018 11:07

To: Zulkhairul Naim Sidek Ahmad; Andrew Povey

Cc: University Research Ethics Committee 1

****Please ensure you read the contents of this message. This email has been sent via the Ethical Review Manager (ERM) system on behalf of the University of Manchester.****

Dear Mr Zulkhairul Naim Sidek Ahmad,

Thank you for submitting your amendment request on 10/07/2018 13:15 for project: 2018-0439-6695 ; entitled: Organophosphate exposure and general and reproductive health which has now been approved. Your documentation has been suitably updated to reflect the proposed changes, please ensure you use this documentation.

Please note that if you have submitted revised supporting documents to accompany your amendment request, the approved versions of these are listed in a table below.

Document Type	File Name	Date	Version
Additional docs	review form comment	10/07/2018	1
Additional docs	Participant Information Sheet 4-29062018	29/07/2018	4
Additional docs	Consent form 4 29062018	29/07/2018	4
Additional docs	Interviewquestionnaire 4 29062018	29/07/2018	4
Additional docs	Selfreportedsymptoms 4 29062018	29/07/2018	4
Additional docs	Saliva collection leaflet	29/07/2018	4

We wish you every success with the research.

Best wishes,

Ms Kate Hennessy

Secretary to University Research Ethics Committee 1

Appendix 4: Research Ethics Amendment Approval for Main Study (Malaysia)

JAWATANKUASA ETIKA & PENYELIDIKAN PERUBATAN
(*Medical Research & Ethics Committee*)
KEMENTERIAN KESIHATAN MALAYSIA
d/a Institut Pengurusan Kesihatan
Jalan Rumah Sakit, Bangsar
59000 Kuala Lumpur

Tel.: 03-2287 4032/2282 0491/2282 9085
03-2282 9082/2282 1402/2282 1449
Faks: 03-2282 0015

Ref : KKM/NIHSEC/ P17-848 (16)
Date: 05-September-2018

DR ZULKHAIRUL NAIM BIN SIDEK AHMAD
UNIVERSITY OF MANCHESTER

Dear Sir/ Mdm,

AMENDMENTS FOR STUDY: NMRR-17-424-34635 (IIR)
Protocol No :
Organophosphate exposure and general and reproductive health among farmers in Kelantan; A longitudinal study

Your amendment submission dated 30-August-2018 is referred.

2. Amendments of the following have been received and reviewed with reference to the above study:

Documents received and reviewed with reference to the above study:

1. Study protocol Version 5, dated 30/08/2018
2. Participant Information Sheet Version 4, dated 29/07/2018 (Eng and Malay version)

The Medical Research & Ethics Committee, Ministry of Health Malaysia operates in accordance to the International Council for Harmonization of Technical Requirement for Pharmaceutical for Human Use (ICH)

Comments (if any): NIL

Decision by Medical Research & Ethics Committee:
(√) Approved via Expedited Review
(   ) Disapproved

Date of Decision: 04-September-2018

....
DR HJH SALINA BT ABDUL AZIZ
Chairperson
Medical Research & Ethics Committee
Ministry of Health Malaysia

HM/AmendmentApproval2018/Mrecshare

Appendix 5: Introductory letter

Centre for Occupational and Environmental Health,
Ellen Wilkinson Building,
Faculty of Biology, Medical and Human Science
The University of Manchester

Dear

Organophosphate exposure and general and reproductive health among farmers

Would you be interested in taking part in such a study?

I have included a copy of the screening questionnaire, participant information sheet and consent form with this letter. This study involves competing questionnaire, collection of urine and semen sample, video recording during spraying session. The study is described in greater detail on the participant information sheet provided.

If you have any questions related to the study, please call the study team on phone number and they will be pleased to help you.

We hope that you are willing to participate and we appreciate your co-operation.

Yours sincerely,

Appendix 6: Participant Information Sheet (Pilot study)

The University of Manchester

Participant Information Sheet

<u>Organophosphate exposure and general and reproductive health among farmers: A longitudinal study</u>

You are being invited to take part in a research study to investigate the association between pesticide use and general and reproductive health effect among farmers in Malaysia.

Before you decide, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully. Please ask if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

Who will conduct the research?

This study is being conducted by

a) Mr Zulkhairul Naim Bin Sidek Ahmad - a PhD student from Centre for Occupational and Environmental Health, School of Health Sciences, Faculty of Biology, Medicine and Health, University of Manchester, M13 9PL and and principle investigator in site from Faculty of Medicine and Health Sciences, University Malaysia Sabah, 88400 Kota Kinabalu, Sabah, Malaysia
b) Dr. Andrew Povey, Principle investigator, Centre for Occupational and Environmental Health, School of Health Sciences, Faculty of Biology, Medicine and Health, University of Manchester, M13 9PL.
c) Prof Daniel Brison, Co- Principle investigator, Department of Reproductive Medicine, St Mary's Hospital, Central Manchester University Hospitals NHS Foundation Trust, Manchester Academic Health Sciences Centre, Oxford Road, Manchester M13 9WL
d) Professor Martie van Tongeren, Centre for Occupational and Environmental Health, School of Health Sciences, Faculty of Biology, Medicine and Health, University of Manchester, M13 9PL.

Who will sponser this research?

This reseach will be funded by The University of Manchester.

What are the aims of the research?

The aims of this study are to investigate the association between pesticides and general and reproductive health effects during spraying and non-spraying seasons among farmers.

Why have I been chosen?

We have randomly choose farmers aged 18 years and above from an agricultural community in three districts namely Ranau, Kota Marudu and Pitas, whose main products are vegetables surrounded the community. The total participants will be approximately 150 participants.

What would I be asked to do if I took part?

If you decide to take part, an appointment will be made for subsequent interview. The data will be collected include questionnaire, diary self-reported symptoms, urine collection and semen collection. For those farmers who unable to read and write, research team will help them. There will be five visits all together.

a) The questionnaire will be administrated during the visit 1, 2, 4 and 5 to obtain information on demographic information, lifestyle factors, and general health, work related and pesticide use, knowledge and practice of pesticide use. There will be screening questionnaire, hospital visit questionnaire and direct interview questionnaire. Screening questionnaire will be distributed during first visit after taking consent and will take about approximately 15 minutes to complete. The interview questionnaire will be done during second visit and will take approximately 30 minutes and hospital visit questionnaire will be distributed during the fourth and fifth visit and will take about 10 minutes to complete the questionnaire.
b) Observation during spraying season will done during third visit. You will be observed by the researcher during the third visit on one working day when they spraying. Your spraying work will be recorded on video .The duration of observation will be depending on the length of spraying period and will take approximately 30 minutes to complete.
c) Information on signs and symptoms such as shortness of breath, palpitation, tremor, sore throat, cough will be collected by using a diary self-reported and information about pesticide spraying which will be filled in by you at the end of each working day (during a week) during visit 3. This diary will take approximately 5 minutes per day.
d) Urine samples will be collected by you at the end of the shift and first morning urine sample after applying organophosphate and kept in a refrigerator until it is picked up by researcher team and store at laboratory at respective hospital. Another urine sample will be collected during hospital visit (visit 4) during non-spraying season. The sample will be transported to laboratory in United Kingdom. During transportation, the samples need to store on dry ice. The sample will be disposed as waste material after used.
e) You will be asked to go to hospital for semen sample collection. Semen sample will be collected at 6-8 weeks and 3-9 months after spraying session. You will be instructed to abstain from intercourse or any others forms of masturbation 2-3 days before collection of the semen. You need to avoid using any forms of container or condom because they might not be clean or contain chemicals which will contaminate the semen. On the day of appointment, semen collection will take place in a private

room in the clinic. You will be provided with clean and dry container. The sample will be collected by masturbation and all the semen ejaculated be collected direct into the container. You need to make sure that the semen is not exposed to overheat or to the air conditioner. Semen sample collected will be used for research purposes as the aim of the study is to look at the potential effects of pesticides on semen quality. It will not be used to diagnose the individual man as having poor semen quality.

What are the possible advantages, disadvantages and risks of taking part?

For the individual participants there are unlikely to be any expected benefits. Overall the study may help to identify factors which influence pesticide exposure (and hence could lead to a reduction in pesticide exposure) but also help to examine associations between pesticide exposure and ill-health and semen quality.

The disadvantage is that you will be interview, observed during spraying, need to answer questionnaire and collection of urine and semen sample. In additional, you may feel the study takes up your time.

Where will research take place?

The research will be take place at the farm where at Ranau, Kota Marudu and Pitas, Sabah, Malaysia. Further analysis of data will be done at The University of Manchester, United Kingdom.

What happens to the data collected?

All research documents will be treated confidentially and will be stored on password protected university server and/or in secured filing cabinets. When disseminating the research results, no identifying information will be published. Only the research team will have access to the study data.

What happens if I do not want to take part or if I change my mind?

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and would ask you to sign a consent form. If you decide to take part you are still free to withdraw at any time without giving a reason and without detriment to yourself. You will be informed if new information becomes available relevant to consent. Withdrawal of consent will not affect your medical services entitled

What are the circumstances that may lead to the termination of a subject's participation may be terminated?

This is an observational study (and not a clinical trial) and it is not anticipated that there are any such circumstances

What is the duration of subject's participation?

The duration of the research will be 3- 9 months to cover both spraying and non-spraying session.

Will the outcomes of the research be published?

We will publish the results in a scientific journal and present them at scientific meetings. We can send you a short communication about our findings, if you wish.

Will the participants will be informed if abnormal semen analysis results?

This is a research study and the semen analysis will not form part of a diagnostic test and hence he would not be informed of the quality of his semen/sperm.

Will I get paid for participating in this study?

The research team will visit farmers for the first, second and third visits. So, no reimbursement will be given. Reimbursement for travelling and food will be given with total of RM 150 and RM 150 at the end of fourth and fifth visit, respectively.

How is the confidentiality of data secured?

All the paper data (hard copy data) and video-recorded data will be transferred from Malaysia to UK by an established international currier. Precautions will be taken to ensure confidentiality of the data and to ensure data are stored securely. For example; 1) all participants will be assigned a specific code so that name of the participants will not be appear on the questionnaire, 2) all the faces or identifying material of the participants in the video recording will be blurred by the researcher before transported to UK, 3) all the data collected will be accessed by the researcher and the research team only and 4) data will be stored on the password protected personal devices. Then, after arrival in Manchester, the paper data files will be securely stored in secured university filing cabinets and will not contain identifying information. The video-recording will be stored on a password protected university server (p-drive). All hard copy information will be securely stored at the University of Manchester for 10 years following completion of the study, after which it will be disposed of securely. The video recording will be deleted after analysis.

Is it I will be informed if new information becomes available relevant to consent?

You will be informed if new information becomes available relevant to consent.

Name and Institution of investigators

If you have any questions or further clarification is needed on a matter, you can contact the following researchers by telephone or email.

Mr Zulkhairul Naim Bin Sidek Ahmad, PhD student, Centre for Occupational and Environmental Health, Faculty of Biology , Medical and Human Science, The University of Manchester and Faculty of Medicine and Health Sciences, University Malaysia Sabah, 88400 Kota Kinabalu, Sabah, Malaysia. zulkhairulnaim.sidekahmad@postgrad.manchester.ac.uk, Tel: 60172341457

Dr. Andrew Povey, Reader in Molecular Epidemiology, Centre for Occupational and Environmental Health, Faculty of Biology , Medical and Human Science, The University of Manchester, andy.povey@manchester.ac.uk

Prof Daniel Brison, Department of Reproductive Medicine, St Mary's Hospital, Central Manchester University Hospitals NHS Foundation Trust, Manchester Academic Health Sciences Centre, Oxford Road, Manchester M13 9WL

Professor Martie van Tongeren, Centre for Occupational and Environmental Health, School of Health Sciences, Faculty of Biology, Medicine and Health, University of Manchester, M13 9PL.

If you wish to make a formal complaint about the conduct of the research you can contact a Research Governance and Integrity Manager, Research Office, Christie Building, University of Manchester, Oxford Road, Manchester, M13 9PL, by emailing: research.complaints@manchester.ac.uk or by telephoning 44 161 275 2674 or 275 8093

Appendix 7: Consent form (Pilot Study)

The University of Manchester
MANCHESTER 1824

CONSENT FORM FOR FARMERS

Organophosphate exposure and general and reproductive health among farmers: A longitudinal study

If you are happy to participate please complete and sign the consent form below

	Initial box
I confirm that I have read the attached information sheet on the above project and have had the opportunity to consider the information and ask questions and had these answered satisfactorily.	
I understand that my participation in the study is voluntary. If I decide to take part, I am still free to withdraw at any time without giving a reason and without detriment to me. Withdrawal of consent will not affect my medical services entitled.	
I agree to my work being observed and video-recorded during working day.	
I agree to give urine samples for this study and I know how they will be collected. I understand that the samples will be used for medical research and after use; the samples will be treated and disposed as clinical waste.	
I agree to give semen samples for this study and I know how they will be collected. I understand that the samples will be used for medical research and after use; the samples will be treated and disposed as clinical waste.	
I understand that any research data will be shared in anonymous form e.g., in conference presentations and scientific articles with my identity will remain confidential.	
I understand that there is reimbursement for travel and food.	

	Please tick if you wish us to send you a short communication about the findings.

I agree to take part in the above project.

Name of participant: ________________________ Signature: ________________________ Date: ____________________

Name of person taking consent number: ________________________ Signature: ________________________ Date: ____________________

I agreed that any data collected may be archived and used for future research projects

Name of participant: ________________________ Signature: ________________________ Date: ____________________

Name of person taking consent: ________________________ Signature: ________________________ Date: ____________________

Appendix 8: Screening Questionnaire

MANCHESTER 1824
The University of Manchester

ORGANOPHOSPHATE PESTICIDES EXPOSURE AND GENERAL AND REPRODUCTIVE HEALTH- A LONGITUDINAL STUDY

SCREENING QUESTIONNAIRE

ID LABEL:

NAME ______________________

ADDRESS ______________________

____

PHONE NUMBER ______________________

DATE QUESTIONNAIRE COMPLETED ______________________

INTRODUCTION

This screening questionnaire asks about current health status and neurodegenerative disorder symptoms and will take approximately about 15 minutes. Please answer all the questions. All information from this questionnaire will be used only by researchers. The results of this study will only be presented as group and analysed anonymously and confidentially.

Thank you very much for your participation in this questionnaire

1 Would you describe your general health as;

Very good	
Good	
Average	
Poor	
Very poor	
Don't know	

2 Do you have any following medical problems or illness ?

Symptom	Yes	No
a) Heart disease including angina		
b) High blood pressure		
c) Anxiety		
d) Parkinson's disease		
e) Asthma		
f) Diabetes		
g) Depression		
h) Stress		

3. In the last three months, have you had any illness that has been caused or made worse by your work

Yes	
No (Please go to question 4)	

3.1 If yes, how would you describe that illness ?

Condition	Please tick
Lung and airways diseases	
Nervous system	
Heart and blood vessels	
Muscle and skeleton	
Eye disorder	
Skin disorder	
Kidney disorder	
Intestinal disorder	
Other Please describe ……….	

4 During the last 4 weeks, how much have you been bothered by any of the following problems?

Symptom	Not bothered	Bothered a little	Bothered a lot
Stomach pain			
Back pain			
Pain in your arms, legs, or joints			
Pain or problems during sexual intercourse			
Headache			
Chest pain			
Dizziness			
Fainting spells			
Feeling your heart rate or race			
Shortness of breath			
Constipation, loose bowels or diarrhoea			
Nausea, gas or indigestion			
Excessive sweating			

5 During the last 4 weeks, how much have you been bothered by any of the following problems?

Symptom	Not bothered	Bothered a little	Bothered a lot
Doing up buttons on your clothes			
Your hands shaking			
Clumsiness			
Slurring your words			
Feeling unsteady when walking			
Problems when using the telephone or cooking a meal			
Moving more slowly or stiffly			
Walking with a stooped posture			
Not swinging your arms when you walk as much as you used to			
Slowing down physically			
Difficulty in turning over in bed at night			
Difficulty in standing up from a chair			
Losing your balance			
Loss of sensation in your hands and feet			
Feeling drunk when you haven't drunk too much			
Cold hands or feet			
Cramps or spasms in your muscles			
Having a weak feeling in yours arms and legs			

6 Over the last 2 weeks, how often have you been bothered by any of the following problems?

Symptom	Not bothered	Bothered a little	Bothered a lot
Little interest or pleasure in doing things			
Feeling down, depressed or hopeless			
Troubling falling or staying asleep			
Sleeping too much			
Feeling tired or having little energy			
Poor appetite or overeating			
Feeling bad about yourself or that you are a failure or have let yourself or your family down			
Trouble concentrating on things, such as reading the newspaper or watching television			
Moving or speaking so slowly that other people could have noticed			
Being so fidgety or restless that you have been moving around a lot more than usual			
Thoughts that life is not worth living			

7 Over the last 2 weeks, how often have you been bothered by any of the following problems?

Symptom	Not bothered	Bothered a little	Bothered a lot
Do you often repeat yourself or ask the same question over and over?			
Are you more forgetful, that is, having trouble with short-term memory?			
Do you need reminders to do things like chores, shopping or taking medicine?			
Do you forget appointments, family occasions or holidays?			
Are you sad, down in the dumps or cry more often than in the past?			
Have you started having double doing calculations, managing finances or balancing the chequebook?			
Have you lost interest in your usual activities such as hobbies, reading, church or other social activities?			
Have you started needing help eating, dressing, bathing or using the bathroom?			
Have you become irritable, agitated or suspicious, or started seeing, hearing or believing things that are not real?			

Are you concerned about your driving, for example, getting lost or driving unsafely?			
Do you have trouble finding the words you want to say, or naming people or things?			
Do you think you're having trouble with your nerves?			

8 During the last 4 weeks, have you had any tablets or any other treatment for the following?

Symptom	Yes	No
Heart disease including angina		
High blood pressure		
Anxiety		
Parkinson's disease		
Asthma		
Diabetes		
Depression		
Stress		

Appendix 9: Interview Questionnaire (Pilot Study)

MANCHESTER 1824

The University of Manchester

ORGANOPHOSPHATE PESTICIDES EXPOSURE AND GENERAL AND REPRODUCTIVE HEALTH- A LONGITUDINAL STUDY

QUESTIONNAIRE (DURING HOME VISIT)

ID LABEL:

NAME	______________________
ADDRESS	______________________
	______________________
PHONE NUMBER	______________________
DATE QUESTIONNAIRE COMPLETED	______________________

INTRODUCTION

This questionnaire asks about demographic, lifestyle factors, current health status, reproductive history, work related information, farming and spraying information re-entry to farming area and knowledge and practice of pesticide use. The interview will take approximately about 15 minutes. Please answer all the questions. All information from this questionnaire will be used only by researchers. The results of this study will only be presented as group and analysed anonymously and confidentially.

Thank you very much for your participation in this questionnaire

PART A: ABOUT YOU

1 What is your date of birth ? ____________________

2 How tall are you ? ____________________cm

3 How much do you weigh ? ____________________kg

4 What is your ethnicity ?

Malay	
Chinese	
Indian	
Other	

5 What is your marital status ?

Single	
Married	
Widowed	
Divorced	

6 What is your educational level ?

Never been to school	
Primary school	
PMR/LCE/SRP	
SPM/MCE/SPMV	
STPM/A Level	
University	

7 What is your income per month ?

Low income (< RM1000)	
Lower middle income (RM 1000- RM 2999)	
Upper middle income (RM 3000- RM 5999)	
High income (more than RM 6000)	

PART B: LIFESTYLE FACTORS

1 Have you ever smoked on daily basis ?

Yes	
No (Please go to question 2)	

1.1 If yes, what age did you start smoking ? ____________years

1.2 Are you still smoking ?

Yes	
No (Please go to question 1.4)	

1.3 If yes, how many cigarettes do you smoke per day on average ? ____________________

1.4 If no, how many years ago did you stop smoking ? ____________years ago

2 Do you drink alcohol ?

Yes	
No (Please go to question 3)	

2.1 If yes, how often do you drink one glass or more of alcohol ?

6-7 days a week	
3-5 days a week	
1-2 days a week	
1-3 days per month	
Less than 1 day a month	

3 How would you describe your current diet habit ?

Vegan	
Vegetarian	
Meat eater	
Fish eater	
Meat and fish eater	

3.1 How would you describe your diet habit two years ago ?

Vegan	
Vegetarian	
Meat eater	
Fish eater	
Meat and fish eater	

PART C : REPRODUCTIVE HISTORY

1 Have you ever been investigated for fertility problems before ?

Yes	
No (Please go to question 2)	

1.1 Do you have any specific infertility problem

Yes	
No (Please go to question 1.3)	

1.2 If yes, please specify the specific type of infertility problem, ______________________

1.3 Have you ever had a semen test ?

Yes	
No (Please go to question 2)	

1.4 If you have had a semen test, when was the most recent ? (please give date mm/yyyy) _________________

1.5 Have you been give the results of the test ?

Yes	
No	

2 Do you have any children with your current partner ?

Yes	
No	

2.1 If yes, how many children do you have ? ________________

PART D : WORK RELATED INFORMATION

Occupational information

1 How long have you worked as a farmer ? ______________ years

2 At what age do you start working ? ___________ years old

3 Since you started working, please describe what job you have carried out for at least 3 months

Job title	Type of work	Type of company	Start mm/yy	Finish mm/yy
Example: Taxi driver	*Driving*	*SK Company*	*07/17*	*10/17*

4 What is the size of your farm ?

Paddy field	___ acre
Crop land	___ acre
Vegetable land	___ acre
Other	___ acre

5 Do you own your farm ?

Yes (Please go to question 6)	
No	

5.1 If no, please specify what your job is at this farm ? ____________________

6 If this is your farm, do you employ any labour on your farm ?

Yes	
Sometime	
No	

PART E : FARMING AND SPRAYING INFORMATION

Farming information

1 What crops are you currently growing ? ____________________

1.1 How many different type of crops did you grow per year ? ___________crops/year

1.2 How many times you harvest the crops per year ?

Type of crops	Times of harvest/year
1.	
2.	
3.	
4.	
5.	

Spraying information

2 How many different type of crops do you spray each year ? ___________crops/year

2.1 How many times you spray the crops per year ?

Type of crops	Times of harvest/year
1.	
2.	
3.	
4.	
5.	

Pesticide use and work practices information

3 When using pesticides, which of the following tasks are you involved in ? (please tick all boxes that apply)

Diluting concentrate	
Preparation	
Spraying	
Others(please specify)	

4 How many days on average per week do you work with pesticides in the spraying season ?

1 day or less	
2-3 days	
4-5 days	
6-7 days	

5 How many hours on average per day do you normally work with pesticides in the spraying season ?

____

6 When was the last time you sprayed ?

____

7 Do you mix the pesticide as well ?

Never (Please go to question 8)	
<50% of the time	
>50% of the time	

7.1 If you mix, do you use an enclosed mixing system ?

Yes	
No	

8 What application method do you mainly use when you apply pesticides ?

Backpack sprayer	
Power sprayer	
Hand gun sprayer	
Others(Please specify)	

8.1 Do you use any other application method as well when you apply pesticides ?

Backpack sprayer	
Power sprayer	
Hand gun sprayer	
Others(Please specify)	

9 Do you use safety/protective equipment during use pesticides ?

Yes	
No	

10 What do you usually wear while applying pesticides ? (please tick all boxes that apply)

Hat	
Goggles	
Dusk mask	
Other type of mask	
Face shields	
Gloves	
Long sleeve shirt	
Shirt	
Apron	
Chemically resistant	

suit	
Long trousers	
Short	
Chemically resistant boots	
Shoes	
Others(please specify)	

11 If you use fabric gloves, how often do you replace old gloves ?

Change after each use	
Change one a month or 1-4 times per season	
Change when they are worn out	

12 If you use leather gloves, how often do you replace old gloves ?

Change after each use	
Change one a month or 1-4 times per season	
Change when they are worn out	

13 When do you change into clean clothes ?

Right away	
Later at the end of the day	
Next day or later in the week	

14 When do you shower and wash your hands/arms ?

Hands/ arms washed right away	
Bath/shower right away	
Bath/shower at lunch	
Bath/shower at the end of the day	

15 If the pesticide was spilt on you, when do you change your clothes ?

Right away	
At lunch	
At the end of the day	
Later in the week	

16 Do you wash the equipment used to apply the pesticides ?

Yes	
No (Please go to question 17)	

16.1 How frequently do you wash the equipment after use ?

Always	
Most of the time	
Half of the time	
Sometimes	

16.2 Where do you usually wash the equipment used to apply the pesticides ?

Farm	
Home	
Others(please specify)	

16.3 When you clean the equipment ?

Hose down the sprayer	
Hose down the tractor	
Clean nozzle	
Rinse tank	
Or other method (please specify)	

16.4 What you usually use to clean the equipment ?

Sand	
Water	
Cloth	
Water and soap	
Cleaning agent	
Others (please specify)	

17 Do you usually repair your own spraying or mixing equipment ?

Yes	
No	

18 Have you ever had an incident or accident while using any type of pesticides which caused an unusually high personal exposure ? e.g. spillage

Yes	
No (Please go to question 19)	

18.1 What happened ? Please give more detail

____

18.2 How often has such an incident happen ?

Less than one day per month	
Less than one day a week	
1-2 days per week	
3-5 days per week	
Everyday	

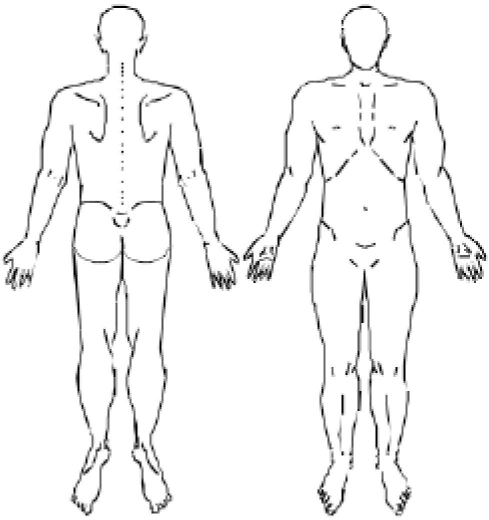
18.3 When was the last time an incident like this happen ?
It happened : _____day, and ______months and _______years ago

18.4 What was the pesticide you were using during your highest exposure incident or accident ?

____

____

19 When you use pesticides, which part of the body usually come into contact with pesticides?
(Please mark on diagram the areas that get wet)



20 Are agricultural or commercial pesticides ever stored (even temporarily) in your home ? (Mark all that apply)

Yes, in home	
Yes, in garage	
Yes, in attached out building	
No	

21 What pesticides do you currently use ?

Crop	Brand name of pesticides	How many times per year ?	How much on average per year ? (litre/gram)

PART F : REENTRY TO FARMING AREA

Working in the field while somebody else sprays

1 Do you work in the field while someone else sprays ?

Yes	
No (Please answer question 6)	

2 If yes how often do you do so ?

Seldom (At least once per year)	
Sometimes (At least once per spray season)	
Often (At least once per month)	
Always	

3 What do you do ?

Harvest vegetables	
Unplug grass	
Packing	
Others, please specify	

4 Do you wear any personal protective equipment ?

Yes	
No (Please answer question 5)	

4.1 How often do you replace your personal protective equipment ?

Change after each use	
Change 2 times a year	
Change once a year	
Use it until worn out	

4.2 What do you usually wear ?

Hat	
Goggles	
Dusk mask	

Other type of mask	
Face shields	
Gloves	
Long sleeve shirt	
Shirt	
Apron	
Chemically resistant suit	
Long trousers	
Short	
Chemically resistant boots	
Shoes	
Others(please specify)	

5 After working in the field do you wash or shower ?

No	
Immediately wash hands	
Take shower just after work	
Immediately wash and shower	

<u>Working in a pesticide sprayed field</u>

6 Do you work in a pesticide sprayed field ?

Yes	
No (Please go to part G)	

7 If yes how often do you do so ?

Seldom (At least once per year)	
Sometimes (At least once per spray season)	
Often (At least once per month)	
Always	

8 What do you do ?

Harvest vegetables	
Unplug grass	
Packing	
Others, please specify,	

9 Do you wear any personal protective equipment?

Yes	
No (Please answer question 10)	

9.1 How often do you replace your personal protective equipment?

Change after each use	
Change 2 times a year	
Change once a year	
Use it until worn out	

9.2 What do you usually wear?

Hat	
Goggles	
Dusk mask	
Other type of mask	
Face shields	
Gloves	
Long sleeve shirt	
Shirt	
Apron	
Chemically resistant suit	
Long trousers	
Short	
Chemically resistant boots	
Shoes	
Others(please specify)	

10 After working in the field do you wash or shower?

No	
Immediately wash hands	
Take shower just after	
Immediately wash and shower	

PART G : KNOWLEDGE OF PESTICIDE USE

Num	Statement	True	False	Don't know
1.	Reading the label on the bottle of pesticide is very important before using pesticides			
2.	An organochlorine is an insecticide			
3.	Carbamate is a rat poison			
4.	Full use of personal protective equipment (PPE) is not required when using pesticides in hot weather			
5.	Areas that have been sprayed cannot be entered again immediately after spraying			
6.	A Hat is important to wear during spraying			
7.	Goggles are not personal protective equipment (PPE)			
8.	Long sleeves and long pants are to be worn during pesticide spraying			
9.	Shoes are not important to wear when spraying pesticides			
10.	Pesticide residues can be removed anywhere			
11.	Eating or drinking during the spraying of pesticides should be avoided			
12.	Cramping legs and arms is one of the symptoms of pesticide use			
13.	Gloves are very important to wear during the spraying			

PART H : PRACTICE OF PESTICIDE USE

What do you do before spraying?					
Question	Always	Very often	Sometimes	Seldom	Never
1)Read the label					
2)Mixed pesticides by hand					
3)Sniffed the pesticides					
4)Mixed pesticides with other materials					
5)Checked spraying equipment					
What do you do during spraying?					
Question	Always	Very often	Sometimes	Seldom	Never
6)Drinking					
7)Eating					
8)Smoking					
9)Spraying in the morning					
10)Spraying upwind					
What do you do after spraying?					
Question	Always	Very often	Sometimes	Seldom	Never
11)Change clothes immediately					
12)Wash hands and face immediately					
13)Shower immediately					
14)Store pesticides in cabinets					
15)Dispose of pesticides in river					
16)Pesticide bottle washing in the river					

Appendix 10: Symptoms Diary

MANCHESTER 1824
The University of Manchester

Information about pesticide spraying and specific symptoms

ID LABEL:

Thank you for agreeing to take part in this research project. We would like to collect information about pesticide use and any specific symptoms you may have after you have started spraying. This diary enables you to record any symptoms you may experience starting on the day you start using pesticides, and continuing for a further 6 days.

Please complete the diary as outlined below. It consists of two parts: the first asks about specific symptoms and the second is about spraying. Answering these diary questions should take about 10-15 minutes. Please try and complete the diary on the actual day itself.

If you have any further inquiry, please contact the one of the research team per below details:
Mr Zulkhairul Naim Bin Sidek Ahmad, PhD student, Centre for Occupational and Environmental Health, Faculty of Biology , Medical and Human Science, The University of Manchester and Faculty of Medicine and Health Sciences, University Malaysia Sabah, 88400 Kota Kinabalu, Sabah, Malaysia. zulkhairulnaim.sidekahmad@postgrad.manchester.ac.uk, Tel: 60172341457. Once again, we appreciate your participation in this study.

PART 1: SPECIFIC DIARY SYMPTOMS

Did you feel ill the day before you started using pesticides?

Yes	
No	√

If yes, please describe the symptoms you had ______________________

In the following example, on the first day of spraying which on 10/07/2017 the participants started to feel unusually tired, tremor and eye irritation. The next day, the participants did not spray and all the symptoms had gone by next day.

	Example 1	Example 2	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Date (dd/mm/yy)	10/07/2017	11/07/2017							
a) Feeling generally ill									
b) Feeling unusually tired	√								
c) Headache									
d) Anxiety									
e) Tremor	√								
f) Palpitation									
g) Sweaty, shivery, feverish,									
h) Pain in your muscles or joints									
i) Runny, stuffy, blocked or irritated nose									
j) Hoarse voice									
k) Sore throat									
l) Cough									
m) Shortness of breath									
n) Wheeze									
o) Nausea and vomiting									
p) Poor appetite									
q) Abdominal cramp									
r) Diarrhoea									
s) Dry mouth, lips and eyes									
t) Increased thirst									
u) Passing less urine									
v) Urine more yellowish than normal									
w) Eye irritation	√								
x) Other(specify)									

PART 2: INFORMATION ABOUT PESTICIDE EXPOSURE

We would also like to obtain some information about your pesticide use during this week.

Day 1 (First day of spraying)		
Date(dd/mm/yy)		
1 What type of crop did you spray today?		
1.1 What is the name of the pesticides you used?		
1.2 At what time did you start spraying?		
1.3 How long did spraying take?(in hours)		
1.4 How much concentrate did you use?		
1.5 What application method did you use?	Backpacker sprayer	
	Power sprayer	
	Other, please specify	
1.6 Did you personally repair the application equipment today?	Yes	
	No	
1.7 Did you wash the pesticide equipment after used?	No	
	Hose down the sprayer/tractor	
	Clean nozzle	
	Rinse tank	
1.8 What do you usually wear while applying pesticides? (please tick all boxes that apply)	1Hat	
	2Goggles	
	3Dusk mask	
	4Other type of mask	
	5Face shields	
	6Gloves	
	7Long sleeve shirt	
	8Short sleeve shirt	
	9Apron	
	10Chemically resistant suit	
	11Long trousers	
	12Short trousers	
	13Chemically resistant boots	
	14Shoes	
	Other (please specify)	
1.9 Which part(s) of your body was exposed to the pesticide? (Mark all that apply.)	1Head and/or face	
	2Arms	
	3Chest/back/abdomen	
	4Legs	
	5Feet	
	Other, please specify	
1.10 Did you mix the pesticide today?	Yes	
	No	
1.11 If you mixed today, did you use an enclosed mixing system?	Yes	
	No	

Day 2		
Date(dd/mm/yy)		
1 What type of crop did you spray today?		
1.1 What is the name of the pesticides you used?		
1.2 At what time did you start spraying?		
1.3 How long did spraying take?(in hours)		
1.4 How much concentrate did you use?		
1.5 What application method did you use?	Backpacker sprayer	
	Power sprayer	
	Other, please specify	
1.6 Did you personally repair the application equipment today?	Yes	
	No	
1.7 Did you wash the pesticide equipment after used?	No	
	Hose down the sprayer/tractor	
	Clean nozzle	
	Rinse tank	
1.8 What do you usually wear while applying pesticides? (please tick all boxes that apply)	Hat	
	Goggles	
	Dusk mask	
	Other type of mask	
	Face shields	
	Gloves	
	Long sleeve shirt	
	Short sleeve shirt	
	Apron	
	Chemically resistant suit	
	Long trousers	
	Short trousers	
	Chemically resistant boots	
	Shoes	
	Other (please specify)	
1.9 Which part(s) of your body was exposed to the pesticide? (Mark all that apply.)	Head and/or face	
	Arms	
	Chest/back/abdomen	
	Legs	
	Feet	
	Other, please specify	
1.10 Did you mix the pesticide today?	Yes	
	No	
1.11 If you mixed today, did you use an enclosed mixing system?	Yes	
	No	

2.0 If you did not spray today, did you work in a field while somebody else sprayed?	Yes (Please answer question 2.1)	
	No (Please answer question 3)	
2.1 What did you do?	Harvest vegetables	
	Weed grass	
	Packing	
	Others, please specify,	
2.2 For how long? (hours)		
2.3 Did you wear any protective equipment?	Yes	
	No	
2.4 If yes, what type of personal protective equipment did you use?	Goggles	
	Dusk mask	
	Other type of mask	
	Face shields	
	Gloves	
	Chemically resistant suit	
	Chemically resistant boots	
2.5 Did you wash or shower after your work?	No	
	Hands/arms washed right away	
	Bath/shower right away	
	Bath/shower later at the end of the day	

3.0 If you did not spray today, did you work in a sprayed field?	Yes (Please answer question 3.1)	
	No (Please answer question 4)	
3.1 What did you do?	Harvest vegetables	
	Weed grass	
	Packing	
	Others, please specify,	
3.2 For how long? (hours)		
3.3 Did you wear any protective equipment?	Yes	
	No	
3.4 If yes, what type of personal protective equipment did you use?	Goggles	
	Dusk mask	
	Other type of mask	
	Face shields	
	Gloves	
	Chemically resistant suit	
	Chemically resistant boots	
3.5 Did you wash or shower after your work?	No	
	Hands/arms washed right away	
	Bath/shower right away	
	Bath/shower later at the end of the day	

4 If you did not sprayed and not working in a sprayed field, what did you do?	

Day 3		
Date(dd/mm/yy)		
1 What type of crop did you spray today?		
1.1 What is the name of the pesticides you used?		
1.2 At what time did you start spraying?		
1.3 How long did spraying take?(in hours)		
1.4 How much concentrate did you use?		
1.5 What application method did you use?	Backpacker sprayer	
	Power sprayer	
	Other, please specify	
1.6 Did you personally repair the application equipment today?	Yes	
	No	
1.7 Did you wash the pesticide equipment after used?	No	
	Hose down the sprayer/tractor	
	Clean nozzle	
	Rinse tank	
1.8 What do you usually wear while applying pesticides? (please tick all boxes that apply)	Hat	
	Goggles	
	Dusk mask	
	Other type of mask	
	Face shields	
	Gloves	
	Long sleeve shirt	
	Short sleeve shirt	
	Apron	
	Chemically resistant suit	
	Long trousers	
	Short trousers	
	Chemically resistant boots	
	Shoes	
	Other (please specify)	
1.9 Which part(s) of your body was exposed to the pesticide? (Mark all that apply.)	Head and/or face	
	Arms	
	Chest/back/abdomen	
	Legs	
	Feet	
	Other, please specify	
1.10 Did you mix the pesticide today?	Yes	
	No	
1.11 If you mixed today, did you use an enclosed mixing system?	Yes	
	No	

2.0 If you did not spray today, did you work in a field while somebody else sprayed?	Yes (Please answer question 2.1)	
	No (Please answer question 3)	
2.1 What did you do?	Harvest vegetables	
	Weed grass	
	Packing	
	Others, please specify,	
2.2 For how long? (hours)		
2.3 Did you wear any protective equipment?	Yes	
	No	
2.4 If yes, what type of personal protective equipment did you use?	Goggles	
	Dusk mask	
	Other type of mask	
	Face shields	
	Gloves	
	Chemically resistant suit	
	Chemically resistant boots	
2.5 Did you wash or shower after your work?	No	
	Hands/arms washed right away	
	Bath/shower right away	
	Bath/shower later at the end of the day	

3.0 If you did not spray today, did you work in a sprayed field?	Yes (Please answer question 3.1)	
	No (Please answer question 4)	
3.1 What did you do?	Harvest vegetables	
	Weed grass	
	Packing	
	Others, please specify,	
3.2 For how long? (hours)		
3.3 Did you wear any protective equipment?	Yes	
	No	
3.4 If yes, what type of personal protective equipment did you use?	Goggles	
	Dusk mask	
	Other type of mask	
	Face shields	
	Gloves	
	Chemically resistant suit	
	Chemically resistant boots	
3.5 Did you wash or shower after your work?	No	
	Hands/arms washed right away	
	Bath/shower right away	
	Bath/shower later at the end of the day	

4 If you did not sprayed and not working in a sprayed field, what did you do?	

Day 4		
Date(dd/mm/yy)		
1 What type of crop did you spray today?		
1.1 What is the name of the pesticides you used?		
1.2 At what time did you start spraying?		
1.3 How long did spraying take?(in hours)		
1.4 How much concentrate did you use?		
1.5 What application method did you use?	Backpacker sprayer	
	Power sprayer	
	Other, please specify	
1.6 Did you personally repair the application equipment today?	Yes	
	No	
1.7 Did you wash the pesticide equipment after used?	No	
	Hose down the sprayer/tractor	
	Clean nozzle	
	Rinse tank	
1.8 What do you usually wear while applying pesticides? (please tick all boxes that apply)	Hat	
	Goggles	
	Dusk mask	
	Other type of mask	
	Face shields	
	Gloves	
	Long sleeve shirt	
	Short sleeve shirt	
	Apron	
	Chemically resistant suit	
	Long trousers	
	Short trousers	
	Chemically resistant boots	
	Shoes	
	Other (please specify)	
1.9 Which part(s) of your body was exposed to the pesticide? (Mark all that apply.)	Head and/or face	
	Arms	
	Chest/back/abdomen	
	Legs	
	Feet	
	Other, please specify	
1.10 Did you mix the pesticide today?	Yes	
	No	
1.11 If you mixed today, did you use an enclosed mixing system?	Yes	
	No	

2.0 If you did not spray today, did you work in a field while somebody else sprayed?	Yes (Please answer question 2.1)	
	No (Please answer question 3)	
2.1 What did you do?	Harvest vegetables	
	Weed grass	
	Packing	
	Others, please specify,	
2.2 For how long? (hours)		
2.3 Did you wear any protective equipment?	Yes	
	No	
2.4 If yes, what type of personal protective equipment did you use?	Goggles	
	Dusk mask	
	Other type of mask	
	Face shields	
	Gloves	
	Chemically resistant suit	
	Chemically resistant boots	
2.5 Did you wash or shower after your work?	No	
	Hands/arms washed right away	
	Bath/shower right away	
	Bath/shower later at the end of the day	

3.0 If you did not spray today, did you work in a sprayed field?	Yes (Please answer question 3.1)	
	No (Please answer question 4)	
3.1 What did you do?	Harvest vegetables	
	Weed grass	
	Packing	
	Others, please specify,	
3.2 For how long? (hours)		
3.3 Did you wear any protective equipment?	Yes	
	No	
3.4 If yes, what type of personal protective equipment did you use?	Goggles	
	Dusk mask	
	Other type of mask	
	Face shields	
	Gloves	
	Chemically resistant suit	
	Chemically resistant boots	
3.5 Did you wash or shower after your work?	No	
	Hands/arms washed right away	
	Bath/shower right away	
	Bath/shower later at the end of the day	

4 If you did not sprayed and not working in a sprayed field, what did you do?	

Day 5		
Date(dd/mm/yy)		
1 What type of crop did you spray today?		
1.1 What is the name of the pesticides you used?		
1.2 At what time did you start spraying?		
1.3 How long did spraying take?(in hours)		
1.4 How much concentrate did you use?		
1.5 What application method did you use?	Backpacker sprayer	
	Power sprayer	
	Other, please specify	
1.6 Did you personally repair the application equipment today?	Yes	
	No	
1.7 Did you wash the pesticide equipment after used?	No	
	Hose down the sprayer/tractor	
	Clean nozzle	
	Rinse tank	
1.8 What do you usually wear while applying pesticides? (please tick all boxes that apply)	Hat	
	Goggles	
	Dusk mask	
	Other type of mask	
	Face shields	
	Gloves	
	Long sleeve shirt	
	Short sleeve shirt	
	Apron	
	Chemically resistant suit	
	Long trousers	
	Short trousers	
	Chemically resistant boots	
	Shoes	
	Other (please specify)	
1.9 Which part(s) of your body was exposed to the pesticide? (Mark all that apply.)	Head and/or face	
	Arms	
	Chest/back/abdomen	
	Legs	
	Feet	
	Other, please specify	
1.10 Did you mix the pesticide today?	Yes	
	No	
1.11 If you mixed today, did you use an enclosed mixing system?	Yes	
	No	

2.0 If you did not spray today, did you work in a field while somebody else sprayed?	Yes (Please answer question 2.1)	
	No (Please answer question 3)	
2.1 What did you do?	Harvest vegetables	
	Weed grass	
	Packing	
	Others, please specify,	
2.2 For how long? (hours)		
2.3 Did you wear any protective equipment?	Yes	
	No	
2.4 If yes, what type of personal protective equipment did you use?	Goggles	
	Dusk mask	
	Other type of mask	
	Face shields	
	Gloves	
	Chemically resistant suit	
	Chemically resistant boots	
2.5 Did you wash or shower after your work?	No	
	Hands/arms washed right away	
	Bath/shower right away	
	Bath/shower later at the end of the day	

3.0 If you did not spray today, did you work in a sprayed field?	Yes (Please answer question 3.1)	
	No (Please answer question 4)	
3.1 What did you do?	Harvest vegetables	
	Weed grass	
	Packing	
	Others, please specify,	
3.2 For how long? (hours)		
3.3 Did you wear any protective equipment?	Yes	
	No	
3.4 If yes, what type of personal protective equipment did you use?	Goggles	
	Dusk mask	
	Other type of mask	
	Face shields	
	Gloves	
	Chemically resistant suit	
	Chemically resistant boots	
3.5 Did you wash or shower after your work?	No	
	Hands/arms washed right away	
	Bath/shower right away	
	Bath/shower later at the end of the day	

4 If you did not sprayed and not working in a sprayed field, what did you do?	

Day 6		
Date(dd/mm/yy)		
1 What type of crop did you spray today?		
1.1 What is the name of the pesticides you used?		
1.2 At what time did you start spraying?		
1.3 How long did spraying take?(in hours)		
1.4 How much concentrate did you use?		
1.5 What application method did you use?	Backpacker sprayer	
	Power sprayer	
	Other, please specify	
1.6 Did you personally repair the application equipment today?	Yes	
	No	
1.7 Did you wash the pesticide equipment after used?	No	
	Hose down the sprayer/tractor	
	Clean nozzle	
	Rinse tank	
1.8 What do you usually wear while applying pesticides? (please tick all boxes that apply)	Hat	
	Goggles	
	Dusk mask	
	Other type of mask	
	Face shields	
	Gloves	
	Long sleeve shirt	
	Short sleeve shirt	
	Apron	
	Chemically resistant suit	
	Long trousers	
	Short trousers	
	Chemically resistant boots	
	Shoes	
	Other (please specify)	
1.9 Which part(s) of your body was exposed to the pesticide? (Mark all that apply.)	Head and/or face	
	Arms	
	Chest/back/abdomen	
	Legs	
	Feet	
	Other, please specify	
1.10 Did you mix the pesticide today?	Yes	
	No	
1.11 If you mixed today, did you use an enclosed mixing system?	Yes	
	No	

2.0 If you did not spray today, did you work in a field while somebody else sprayed?	Yes (Please answer question 2.1)	
	No (Please answer question 3)	
2.1 What did you do?	Harvest vegetables	
	Weed grass	
	Packing	
	Others, please specify,	
2.2 For how long? (hours)		
2.3 Did you wear any protective equipment?	Yes	
	No	
2.4 If yes, what type of personal protective equipment did you use?	Goggles	
	Dusk mask	
	Other type of mask	
	Face shields	
	Gloves	
	Chemically resistant suit	
	Chemically resistant boots	
2.5 Did you wash or shower after your work?	No	
	Hands/arms washed right away	
	Bath/shower right away	
	Bath/shower later at the end of the day	

3.0 If you did not spray today, did you work in a sprayed field?	Yes (Please answer question 3.1)	
	No (Please answer question 4)	
3.1 What did you do?	Harvest vegetables	
	Weed grass	
	Packing	
	Others, please specify,	
3.2 For how long? (hours)		
3.3 Did you wear any protective equipment?	Yes	
	No	
3.4 If yes, what type of personal protective equipment did you use?	Goggles	
	Dusk mask	
	Other type of mask	
	Face shields	
	Gloves	
	Chemically resistant suit	
	Chemically resistant boots	
3.5 Did you wash or shower after your work?	No	
	Hands/arms washed right away	
	Bath/shower right away	
	Bath/shower later at the end of the day	

4 If you did not sprayed and not working in a sprayed field, what did you do?	

Appendix 11: DREAM Questionnaire

MANCHESTER 1824

The University of Manchester

DERMAL EXPOSURE ASSESSMENT METHOD (DREAM)

Thank you for agreeing to take part in the study. In additional to completing questionnaire and collection of urine sample, the participants will be observed by the researcher during the third visit on one working day when they spraying. The participant spraying work will be recorded on video for completion of the structural DREAM checklist. The duration of observation will be depending on the length of spraying period.

DERMAL EXPOSURE ASSESSMENT METHOD (DREAM) – QUESTIONNAIRE PART 1: DEPARTMENT

Observer (fill in your name):		
Company code:		
Department:		
	QUESTION	**ANSWERS**
1	Main activity	
2	Do chemical / biological agents occur at the department or is work environment[1] contaminated?	O no → STOP, fill in next department O yes
3	Who is responsible for cleaning the department / work tables / machines?	O not applicable → 6 O department workers themselves O a special cleaning unit O both
3.1	How often is the floor cleaned?	O daily O weekly O monthly O yearly / never
3.2	How is the floor cleaned?	O dry O wet O both
3.3	How often are worktables cleaned?	O department does not have worktables O daily O weekly O monthly O yearly / never
3.4	How are worktables cleaned?	O dry O wet O both

[1] Includes contaminated surfaces (e.g. contaminated machinery, packing material) and tools

3.5	How often are machines cleaned?	O department does not have machines O daily O weekly O monthly O yearly / never
3.6	How are machines cleaned?	O dry O wet O both
4	How often are non-disposable working tools cleaned?	O tools are not used at the department → 7 O daily O weekly O monthly O yearly / never
4.1	How are non-disposable working tools cleaned?	O dry O wet O both

DERMAL EXPOSURE ASSESSMENT METHOD (DREAM) – QUESTIONNAIRE PART 2: AGENT

Observer (fill in your name):		
Company:		
Department:		
Agent (fill in the agent of interest[2]):		
Date:		
	QUESTION	**ANSWERS**
1	Trade name of agent?[3]	
2	Name of active ingredient of interest?	
3	Estimate absolute concentration of the active ingredient in agent	______ O mg/L O mg/kg O %w/w O % v/v
4	The agent is pure, mixture of a residue?	O pure (≥ 90% active ingredient of interest) O mixture (1-90% active ingredient of interest) O residue (< 1% active ingredient of interest)
5	Specify physical state of agent	O Solid → 5.1 O Liquid → 6.1 O Vapour → next module O Gaseous → next module
5.1	The agent's form	O Powder O Granules O Flocks / shreds / chips / flakes O Pellets O Other specify: ______________________
5.2	Agent is dusty	O no O yes

[2] Agent to which dermal exposure is assessed. Agent may be a mixture of substances (e.g. paint, wood-dust, asphalt fumes).
[3] If applicable.

5.3	Agent is sticky / wax-like / moist?	O no O yes
6.1	The boiling temperature of concerning active ingredient is?	O < 50°C O 50 – 150 °C O > 150 °C O not known
6.2	Viscosity of agent	O Low (like water) O Medium (like oil) O High (like resin/paste)
6.3	Agent sticks (like glue / resin / varnish)?	O no O yes

Observer:						
Company:						
Department:						
Job title:						
	QUESTION			**ANSWERS**		
1	Total number of workers with this job title:					
2	Number of workers per duty/shift:					
3	Mark covered[4,5] body parts			Description of outer layer of clothing		
		No	Yes	Woven[6]	Non-woven[7]	Non-permeable[8]
	Head / neck	O	O	O	O	O
	Upper arms	O	O	O	O	O
	Forearms	O	O	O	O	O
	Wrists / hands	O	O	O	O	O
	Torso (front)	O	O	O	O	O
	Torso (back)	O	O	O	O	O
	Lower abdomen and upper legs	O	O	O	O	O
	Lower legs	O	O	O	O	O
	Feet	O	O	Open shoes O	Closed shoes O	Rubber boots O

[4] A body part is defined as covered when more than 90% of a body part is covered. Do not include TASK SPECIFIC personal protective equipment (PPE). Task specific protective devices are filled in at task level
[5] If workers differ regarding clothing, indicate less covered worker.
[6] Such as cotton / linen / polyester, agent may penetrate.
[7] Such as tyvek / leather, agent may permeate.
[8] Non-woven and non-permeable, agents do not permeate

<table>
<tr><td>4</td><td>Are work clothes immediately changed after work?</td><td colspan="5">O no
O some workers
O yes</td></tr>
<tr><td>5</td><td>How often are work clothes replaced by clean?</td><td colspan="5">O daily
O more times a week
O once a week</td></tr>
<tr><td>6</td><td>Are workers responsible for washing their own work clothes?</td><td colspan="5">O no
O yes</td></tr>
<tr><td>7</td><td>Workers wash their hands during work</td><td colspan="5">O no
O yes</td></tr>
<tr><td>7.1</td><td>Specify how hands are normally washed:</td><td colspan="5"></td></tr>
<tr><td></td><td></td><td>1 / shift end of day</td><td>1 / shift during day</td><td>2-4 / shift</td><td>5-10 / shift</td><td>11-20 / shift</td></tr>
<tr><td></td><td>O only water
O general soap
O scrub soap
O solvents
O other (specify) ____________</td><td>O
O
O
O
O</td><td>O
O
O
O
O</td><td>O
O
O
O
O</td><td>O
O
O
O
O</td><td>O
O
O
O
O</td></tr>
<tr><td>8</td><td>Do workers shower at work?</td><td colspan="5">O no
O some workers
O yes</td></tr>
</table>

Observer (fill in your name):		
Company code:		
Department:		
Job title:		
Task:		
Agent:		
	QUESTION	**ANSWERS**
1	Number of months per year task is performed?	
2	How many workers perform this task?[9]	
3	How many workers perform this task at the same moment?[10]	
4	Task performance [Estimated for **one** general worker with this job title and task]	O daily → 4.1 O weekly O monthly O yearly
4.1	Task frequency per day (Estimated for **one** worker)	O 1 time O 2 – 10 times O > 10 times

[9] Workers with this job title, within this department

		Per day	Per week (Hours)	Per month (Hours)	Per year (Hours)
5	Total time of task performance **(frequency * duration)** *Estimated for one worker*	**O ≤ 10 min** **O 11-60 min** **O >1 – 4 h** **O > 4 – 8 h**	**O 0 – 1** **O >1 – 4** **O >4 – 20** **O >20**	**O 0 – 4** **O > 4 – 16** **O > 16 – 80** **O > 80**	**O 0 – 40** **O > 40 – 160** **O > 160 – 800** **O > 800**
6	Total time of task performance (absolute) *Estimated for one worker*	____ Minutes per day ____ Hours per week / month / year[10]			
7	You observed the task?	O no O yes → 7.1			
7.1	How often did you observe?	O one person once O one person several times O several persons once O several persons, several times			

[10] Strike out whichever not applicable

INSTRUCTIONS

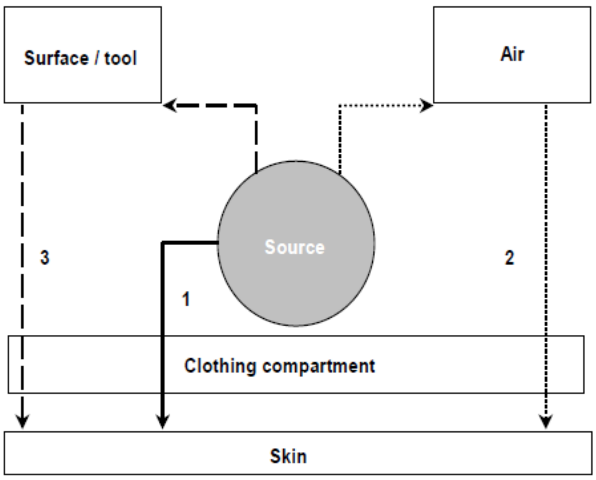
- Choose always the answer closest to your opinion.
- Read footnotes carefully.
- Assess exposure to ONE agent (which can be a complex mixture of substances) at the time.
- The questions consider POTENTIAL dermal exposure, which is defined as dermal exposure on clothing and uncovered skin; if body parts are covered exposure to the covered body parts is assessed. The evaluation part of DREAM takes into account the protective effects of clothing and personal protections devices like gloves etc.
- The questions of DREAM are based on the conceptual model for dermal exposure according to Schneider et al., 1999. This model considers, amongst others, the following exposure routes for dermal exposure (see also figure 1):

Emission: direct release from a source onto skin or clothing, such as exposure by splashes, or immersion of hands into a liquid or powder; droplets and powder particles have an aerodynamic diameter of ≥ 100 micrometer.

Deposition: agent is released to air and subsequently deposited on skin or clothing: e.g. small particles such as vapours, fine dust. Particles have an aerodynamic diameter of less than 100 micrometer; vapour, very small droplets, or fine dust

Transfer: contact with surfaces or working tools that have been previously contaminated with agent.

Figure 1: exposure routes for dermal exposure (1= emission; 2=transfer; 3=deposition).



- After filling in, check whether you marked the body parts you consider to be exposed.
- Please continue

Observer (fill in your name):	
Company Code:	
Department:	
Job title:	
Task:	
Exposure to (fill in agent):	
Date:	
ID of observed worker(s):	

1	**Emission.**[11] (Covered) hands are exposed by direct release of agent from a source or by immersion?	O no, unlikely → 2 O yes, occasionally[12] O yes, repeatedly[13] O yes, almost constantly[14]	
1.1	Specify amount	O small amount (<10% hands) O medium amount (10 – 50% hands) O large amount (> 50% hands)	
2	**Emission.** Other (covered) body parts are exposed by direct release of agent from a source, or by immersion?	O no → 3 O yes, occasionally[13] O yes, repeatedly[14] O yes, almost constantly[15]	
2.1	Specify amount	O small amount (<10% of body part) O medium amount (10 – 50% of body part) O large amount (> 50% of body part)	
2.2	Please tick body parts exposed due to emission	Body part	Contact
		Head / neck	O
		Upper arms	O
		Forearms	O
		Torso (front)	O
		Torso (back)	O
		Lower abdomen and upper legs	O
		Lower legs	O
		Feet	O

[11] **Emission:** direct release from a source onto skin or clothing, such as immersion of hands into a liquid or powder, or exposure by splashes; droplets and powder particles have an aerodynamic diameter of ≥ 100 micrometer.
[12] <10% of task duration
[13] 10-50% of task duration
[14] >50% of task duration

3	**Deposition.**[15] When performing task airborne particles[16] of the agent are formed or present in working environment and deposited on (covered) body parts?	O no, unlikely→ 4 O yes, occasionally/possibly[17] O yes, repeatedly[18] O yes, almost constantly[19]	
3.1	Specify amount	O small amount (<10% body part) O medium amount (10 – 50% body part) O large amount (> 50% body part)	
3.2	Please tick body parts exposed due to deposition	Body parts	Agent deposited.
		Head / neck Upper arms Forearms Hands - wrists Torso (front) Torso (back) Lower abdomen and upper legs Lower legs Feet	O O O O O O O O O

[15] Agent is released to air and subsequently deposited on skin or clothing: e.g. small particles such as vapours, fine dust.
[16] Particles with an aerodynamic diameter of less than 100 micrometer; vapour, very small droplets, or fine dust
[17] <10% of task duration
[18] 10-50% of task duration
[19] >50% of task duration

4	**Transfer of agent to (covered) hands.**[20] When performing this task…								
4.1		**Hands have contact with surfaces or tools?**				**Estimated contamination level of contact surface?**			
	Surfaces[21, 22]**:**	**Unlikely**	**Occasionally**[23]	**Repeatedly**[24]	**Almost constantly**[25]	**Not Contaminated**	**Possibly contaminated**	**< 50% of contact surface**	**> 50% of contact surface**
	Floor	O	O	O	O	O	O	O	O
	Worktables	O	O	O	O	O	O	O	O
	Machines	O	O	O	O	O	O	O	O
	Working tools	O	O	O	O	O	O	O	O
	Other surfaces,	O	O	O	O	O	O	O	O
	4.1.a Other surfaces specification:								

[20] **Transfer:** contact with surfaces or working tools that have been previously contaminated with agent
[21] In case surfaces are not present (e.g. work tables), tick ‘unlikely’.
[22] In case ‘surfaces’ of one category have different contact frequencies or contamination levels, indicate then the surface with the highest product of contact frequency and contamination level in that category.
[23] <10% of task duration
[24] 10-50% of task duration
[25] >50% of task duration

5	**Transfer of agent to other (covered) body parts.** [26] When performing this task[27]…								
5.1		**Other body parts have contact with surfaces, tools or hands?**				**Estimated contamination level of contact surface?**			
	Surfaces:[28,29]	**Unlikely**	**Occasionally**[30]	**Repeatedly**[31]	**Almost constantly**[32]	**Not Contaminated**	**Possibly contaminated**	**< 50% of contact surface**	**> 50% of contact surface**
	Floor	O	O	O	O	O	O	O	O
	Worktables	O	O	O	O	O	O	O	O
	Machines	O	O	O	O	O	O	O	O
	Working tools	O	O	O	O	O	O	O	O
	Hands	O	O	O	O	O	O	O	O
	Other surfaces	O	O	O	O	O	O	O	O
	5.1a Other surfaces specification:								
5.2	Please tick body parts that have contact with contaminated surfaces:				Body part:			Contact	
					Head / neck			O	
					Upper arms			O	
					Forearms			O	
					Torso (front)			O	
					Torso (back)			O	
					Lower abdomen and upper legs			O	
					Lower legs			O	
					Feet			O	

[26] **Transfer:** contact with surfaces or working tools that may have been previously contaminated with agent
[27] Do not consider contact of feet with contaminated floor if footwear is supposed to provide proper protection
[28] In case surfaces are not present (e.g. work tables), tick 'unlikely'.
[29] In case 'surfaces' of one category have different contact frequencies or contamination levels, indicate then the surface with the highest product of contact frequency and contamination level in that category.
[30] <10% of task duration
[31] 10-50% of task duration
[32] >50% of task duration

6	**Contamination.** Indicate how surfaces get contaminated with agent during task.						
6.1		**Contaminated during task?**			**Indicate main route only**		
	Surfaces:	**No**	**Possibly**	**Yes**	**Emission**[33]	**Deposition**[34]	**Transfer**[35]
	Floor	O	O	O	O	O	O
	Worktables	O	O	O	O	O	O
	Machines	O	O	O	O	O	O
	Working tools	O	O	O	O	O	O
	Hands	O	O	O	O	O	O
	Other surfaces	O	O	O	O	O	O
	6.1a Other surfaces specification:						

[33] **Emission:** direct release from source onto surfaces, such as immersion of surfaces into a liquid or powder, exposure by splashes. Droplets and powder particles have an aerodynamic diameter of ≥100 micrometer.

[34] **Deposition:** agent is released to air and subsequently deposited on surface: e.g. small particles such as vapours, fine dust. Droplets and powder particles have an aerodynamic diameter of <100 micrometer.

[35] **Transfer**: contact of surfaces with surfaces or working tools that have been previously contaminated with agent

7	Does worker use gloves when performing task?	O no → 13 O yes
7.1 **ASK**	Specify glove type	O Latex, disposable O Latex, none disposable O Vinyl disposable O Polyvinyl chloride (PVC) O Nitrile rubber O Neoprene rubber O Butyl rubber O Fluorocarbon rubber (e.g. Viton tm) O Laminated, impregnated, coated (e.g. cloth with rubber or leather) gloves O Cotton gloves O Plastic disposable O Leather gloves O Other: ____________________
8	Gloves connect well to clothing of arms?	O no O yes
9	When performing task gloves are worn during:	O 0 – 10 % of task duration O 10 – 50% of task duration O 50 – 100% of task duration
10	Are gloves taken off correctly (skin does not have contact with outer surface gloves)?	O No O Not observed O Yes
11 **ASK**	How often are gloves replaced	O after having used them 1 time O daily O weekly O monthly
12	Does worker wear a second pair of gloves under outer gloves?	O no O yes
12.1 **ASK**	How often are these inner gloves replaced?	O after having used them 1 time O daily O weekly O monthly

13	Is barrier crème used?	O no O yes
14	Does worker use personal protective clothing **in addition to** clothing indicated at job title level?	O no O yes
15	Mark covered body parts[36]	

	Covered?		Material outer layer clothing			How often replaced? (Ask)			
			Woven[37]	**Non-woven**[38]	**Imper-meable**[39]	**After 1 time**	**Daily**	**Week-ly**	**Month ly**
Head / neck	O No	O Yes	O	O	O	O	O	O	O
Upper arms	O No	O Yes	O	O	O	O	O	O	O
Forearms	O No	O Yes	O	O	O	O	O	O	O
Torso (front)	O No	O Yes	O	O	O	O	O	O	O
Torso (back)	O No	O Yes	O	O	O	O	O	O	O
Lower abdomen and upper legs	O No	O Yes	O	O	O	O	O	O	O
Lower legs	O No	O Yes	O	O	O	O	O	O	O
Feet	O No	O Yes	Open shoes O	Closed shoes O	Rubber boots O	Daily O	Weekly O	Month ly O	Yearly O

16 **ASK**	Amount of agent handled during total time of task performance[40]	O _____ O mg O mL O g O L O kg O m3 O not applicable

[36] A body part is defined as covered when >90% is covered.
[37] Such as cotton, linen, polyester
[38] Such as tyvek, plastic, rubber, leather
[39] Both non-woven and non-permeable, which is agent specific, search information if you are not sure!
[40] In case of performing measurements task performance is equal to measurement time.

Appendix 12: Hospital Visit Questionnaire

MANCHESTER 1824

The University of Manchester

ORGANOPHOSPHATE PESTICIDES EXPOSURE AND GENERAL AND REPRODUCTIVE HEALTH: A LONGITUDINAL STUDY QUESTIONNAIRE (DURING HOSPITAL VISIT)

ID LABEL:

NAME ______________________

ADDRESS ______________________

____

PHONE NUMBER ______________________

DATE QUESTIONNAIRE COMPLETED ______________________

INTRODUCTION

This questionnaire asks about semen sample collection, lifestyle factor and current health status.

The interview will take approximately about 10 minutes. Please answer all the questions. All information from this questionnaire will be used only by researchers. The results of this study will only be presented as group and analysed anonymously and confidentially.

Thank you very much for your participation in this questionnaire

PART A: COLLECTION QUESTIONNAIRE

1 Number of days since last ejaculation ____________________

2 Method of collection (Please tick)

Masturbation	
Other	

3 Did any portion of ejaculation miss the container?

Yes	
No (Please go to part B)	

3.1 If yes, the missed portion is from the

Early part of the ejaculation	
Last part of ejaculation	

PART B: LIFESTYLE FACTORS

1 Since we last saw you, have you smoked on regular basis?

Yes	
No (Please go to question 2)	

1.1 If yes, how many cigarettes do you smoke per day on average? ____________________

2 Since we last saw you, do you drink alcohol?

Yes	
No (Please go to question 3)	

2.1 If yes, how often do you drink one glass of alcohol or more?

6-7 days a week	
3-5 days a week	
1-2 days a week	
1-3 days per month	
Less than 1 day a month	

3 Since we last saw you, did you wear tight clothing, equipment or jeans?

Yes	
No	

3.1 Since we last saw you, when not at work do you frequently wear tight trousers?

Yes	
No	

PART C: YOUR CURRENT HEALTH STATUS

1	Since we last saw you, any medical condition that caused you to have radiotherapy, chemotherapy or take immunosuppressant drugs?	Yes	
		No (Please go to question 2)	
1.1	If yes, what was the medical condition and what medication did you take?	____________	
2	Since we last saw you, have you been to hospital to have an x ray or a scan?	Yes	
		No (Please go to question 3)	
2.1	If yes, which type of x ray or scan and when was the last time?	____________	
3	Since we last saw you, have you regularly (at least one a month) used any recreational drugs, or steroids for supporting activities?	Yes	
		No	
4	Since we last saw you, have you had any fever or flu?	Yes	
		No (Please go to question 5)	
4.1	If yes, how long did it last?	______days	
5	Since we last saw you, have you had any illness that have been caused or been made worse by your work?	Yes	
		No	

5.1 If yes, how would you describe the illness?

Illness	Please tick	
Breathing or lung problems		
Skin problems		
Hearing problems		
Stress, depression or anxiety		
Headache and or eye strain		
Infectious disease		
Bone, joint or muscle problems which mainly affect	Arms, hands, neck or shoulder	
	Hips, legs or feet	
	back	

PART D: PESTICIDE EXPOSURE

1 Since we last saw you, did you exposed to pesticide again?

Yes	
No	

1.1 If yes, what type of pesticide did you exposed ______________

Appendix 13: Interview Questionnaire (Main Study)

MANCHESTER 1824
The University of Manchester

PESTICIDES EXPOSURE AND GENERAL AND REPRODUCTIVE HEALTH AMONG FARMERS IN KELANTAN: A LONGITUDINAL STUDY

QUESTIONNAIRE (INTERVIEW)

ID LABEL:

DATE QUESTIONNAIRE COMPLETED ____________________________________

INTRODUCTION

Thank you for agreeing to take part in this study. This questionnaire asks about your lifestyle, current health status, reproductive history, work related pesticide use, knowledge and practice about pesticide use. The interview will take approximately about 15 minutes to complete. All information from this questionnaire will be used only by the study researchers. The results of this study will only be presented as group and analysed pseudo anonymously and confidentially.

If you have any further inquiry, please contact the one of the research team per below details: Mr Zulkhairul Naim Bin Sidek Ahmad, PhD student, Centre for Occupational and Environmental Health, Faculty of Biology , Medical and Human Science, The University of Manchester. zulkhairulnaim.sidekahmad@postgrad.manchester.ac.uk, Tel: 60172341457

Thank you very much for your participation in this questionnaire

PART A: ABOUT YOU

1 What is your date of birth? ______________________________

2 How tall are you? ____________________________cm

3 How much do you weigh? _____________________________kg

4 What is your ethnicity?

Malay	
Chinese	
Indian	
Other	

5 What is your marital status?

Single	
Married	
Widowed	
Divorced	

6 What is your educational level?

Never been to school	
Primary school	
PMR/LCE/SRP	
SPM/MCE/SPMV	
STPM/A Level	
University	

7 What is your income per month?

Low income (< RM1000)	
Lower middle income(RM 1000- RM 2999)	
Upper middle income(RM 3000- RM 5999)	
High income(more than RM 6000)	

PART B: LIFESTYLE FACTORS

1 Have you ever smoked on daily basis?

Yes	
No (Please go to question 2)	

1.1 If yes, what age did you start smoking? ______________years

1.2 Are you still smoking?

Yes	
No (Please go to question 1.4)	

1.3 If yes, how many cigarettes do you smoke per day on average? ______________________

1.4 If no, how many years ago did you stop smoking? ______________years ago

2 Do you drink alcohol?

Yes	
No (Please go to question 3)	

2.1 If yes, how often do you drink one glass or more of alcohol?

6-7 days a week	
3-5 days a week	
1-2 days a week	
1-3 days per month	
Less than 1 day a month	

3 How would you describe your current diet habit?

Vegan	
Vegetarian	
Meat eater	
Fish eater	
Meat and fish eater	

PART C : YOUR CURRENT HEALTH STATUS

1 Would you describe your general health as;

Very good	
Good	
Average	
Poor	
Very poor	
Don't know	

2 Do you have any following medical problems or illness?

Symptom	Yes	No
a) Heart disease including angina		
b) High blood pressure		
c) Anxiety		
d) Parkinson's disease		
e) Asthma		
f) Diabetes		
g) Depression		
h) Stress		

3. In the last three months, have you had any illness that has been caused or made worse by your work

Yes	
No	

3.1 If yes, how would you describe that illness?

Condition	Please tick
Lung and airways diseases	
Nervous system	
Heart and blood vessels	
Muscle and skeleton	
Eye disorder	
Skin disorder	
Kidney disorder	
Intestinal disorder	
Other Please describe ……….	

4 During the last 4 weeks, how much have you been bothered by any of the following problems?

Symptom	Not bothered	Bothered a little	Bothered a lot
a) Stomach pain			
b) Back pain			
c) Pain in your arms, legs, or joints			
d) Pain or problems during sexual intercourse			
e) Headache			
f) Chest pain			
g) Dizziness			
h) Fainting spells			
i) Feeling your heart rate or race			
j) Shortness of breath			
k) Constipation, loose bowels or diarrhoea			
l) Nausea, gas or indigestion			
m) Excessive sweating			

5 During the last 4 weeks, how much have you been bothered by any of the following problems?

Symptoms	Not bothered	Bothered a little	Bothered a lot
a) Doing up buttons on your clothes			
b) Your hands shaking			
c) Clumsiness			
d) Slurring your words			
e) Feeling unsteady when walking			
f) Problems when using the telephone or cooking a meal			
g) Moving more slowly or stiffly			
h) Walking with a stooped posture			
i) Not swinging your arms when you walk as much as you used to			
j) Slowing down physically			
k) Difficulty in turning over in bed at night			
l) Difficulty in standing up from a chair			
m) Losing your balance			
n) Loss of sensation in your hands and feet			
o) Feeling drunk when you haven't drunk too much			
p) Cold hands or feet			
q) Cramps or spasms in your muscles			
r) Having a weak feeling in yours arms and legs			

6 Over the last 2 weeks, how often have you been bothered by any of the following problems?

Symptoms	Not bothered	Bothered a little	Bothered a lot
a) Little interest or pleasure in doing things			
b) Feeling down, depressed or hopeless			
c) Troubling falling or staying asleep			
d) Sleeping too much			
e) Feeling tired or having little energy			
f) Poor appetite or overeating			
g) Feeling bad about yourself or that you are a failure or have let yourself or your family down			
h) Trouble concentrating on things, such as reading the newspaper or watching television			
i) Moving or speaking so slowly that other people could have noticed			
j) Being so fidgety or restless that you have been moving around a lot more than usual			
k) Thoughts that life is not worth living			

7 Over the last 2 weeks, how often have you been bothered by any of the following problems?

Symptoms	Not bothered	Bothered a little	Bothered a lot
a) Do you often repeat yourself or ask the same question over and over?			
b) Are you more forgetful, that is, having trouble with short-term memory?			
c) Do you need reminders to do things like chores, shopping or taking medicine?			
d) Do you forget appointments, family occasions or holidays?			
e) Are you sad, down in the dumps or cry more often than in the past?			
f) Have you started having double doing calculations, managing finances or balancing the chequebook?			
g) Have you lost interest in your usual activities such as hobbies, reading, church or other social activities?			
h) Have you started needing help eating, dressing, bathing or using the bathroom?			
i) Have you become irritable, agitated or suspicious, or started seeing, hearing or believing things that are not real?			

Symptoms	Not bothered	Bothered a little	Bothered a lot
j) Are you concerned about your driving, for example, getting lost or driving unsafely?			
k) Do you have trouble finding the words you want to say, or naming people or things?			
l) Do you think you're having trouble with your nerves?			

PART D : REPRODUCTIVE AND CHILDREN HISTORY

1 Have you ever been investigated for fertility problems before?

Yes	
No(Please go to question 2)	

1.1 Do you have any specific infertility problem

Yes	
No(Please go to question 1.3)	

1.2 If yes, please specify the specific type of infertility problem, ______________________

1.3 Have you ever had a semen test?

Yes	
No(Please go to question 2)	

1.4 If you have had a semen test, when was the most recent? (please give date mm/yyyy) ________________

1.5 Have you been give the results of the test?

Yes	
No	

2 Do you have any children with your current partner?

Yes	
No	

2.1 If yes, how many children do you have? ________________

2.2 If yes, we would like to know detail regarding pregnancy and delivery of your children.

No	Date of delivery	Sex	Place of birth	Duration of pregnancy (Preterm/Term)	Method of delivery (Caesarean/Non-caesarean)	Birth weight	Any complication to the baby and mother during pregnancy	Problem to the baby after birth until 1 month
	Example							
1	**02/02/90**	**Boy**	**Hospital Kota Bharu**	**Term**	**Non-Caesarean**	**3.2 kg**	**Gestational Diabetes on diet control**	**Admitted to Neonatal ward for neonatal jaundice**

PART E : WORK RELATED HISTORY

1 At what age do you start working? _____________ years old

2 Since you started working, please describe what job you have carried out for at least 3 months

Job title	Type of work	Type of company	Start mm/yy	Finish mm/yy
Example: Taxi driver	*Driving*	*SK Company*	*07/17*	*10/17*

3 How long have you worked as a farmer? ____________ years

4 What is the size of your farm?

Paddy field	___ acre
Crop land	___ acre
Vegetable land	___ acre
Other	___ acre

5 Do you own your farm?

Yes(Please go to question 6)	
No	

5.1 If no, please specify what your job is at this farm? ___________________

6 If this is your farm, do you employ any labour on your farm?

Yes	
Sometime	
No	

6.1 If yes, what jobs do your employees carry out? (Please tick all that apply)

Loading	
Mixing	
Equipment cleaning	
Spraying	
Other, please specify	

PART F: FARMING AND SPRAYING INFORMATION

Farming information

1 What crops are you currently growing?

1. 2. 3. 4.

1.1 How many different type of crops did you grow per year? ___________crops/year

1.2 How many times you harvest the crops per year?

Type of crops	Times of harvest/year
1.	
2.	
3.	
4.	
5.	

Spraying information

2 How many different type of crops do you spray each year? ___________crops/year

2.1 How many times you spray the crops per year?

Type of crops	Times of harvest/year
1.	
2.	
3.	
4.	
5.	

PART G: PESTICIDE USE AND WORK PRACTICE INFORMATION

1 What pesticides do you currently use?

Crop	Brand name of pesticides	How many times per year?	How much on average per year?(litre/gram)

2 When using pesticides, which of the following tasks are you involved in? (please tick all boxes that apply)

Diluting concentrate	
Preparation	
Spraying	
Others(please specify)	

3 How many days on average per week do you work with pesticides in the spraying season?

1 day or less	
2-3 days	
4-5 days	
6-7 days	

4 How many hours on average per day do you normally work with pesticides in the spraying season? ____________________

5 When was the last time you sprayed? ____________________

5.1 What type of pesticides did you used

____

____

____

____

6 Do you mix the pesticide as well?

Never	
<50% of the time	
>50% of the time	

6.1 If you mix, do you use an enclosed mixing system?

Yes	
No	

7 What application method do you mainly use when you apply pesticides?

Backpack sprayer	
Power sprayer	
Hand gun sprayer	
Others(Please specify)	

7.1 Do you use any other application method as well

Backpack sprayer	

	when you apply pesticides?	Power sprayer	
		Hand gun sprayer	
		Others(Please specify)	
8	Do you use safety/protective equipment during use pesticides	Yes	
		No	
9	What do you usually wear while applying pesticides? (please tick all boxes that apply)	Hat	
		Goggles	
		Dusk mask	
		Other type of mask	
		Face shields	
		Gloves	
		Long sleeve shirt	
		Shirt	
		Apron	
		Chemically resistant suit	
		Long trousers	
		Short	
		Chemically resistant boots	
		Shoes	
		Others(please specify)	
9.1	If you use fabric gloves, how often do you replace old gloves?	Change after each use	
		Change one a month or 1-4 times per season	
		Change when they are worn out	
9.2	If you use leather gloves, how often do you replace old gloves?	Change after each use	
		Change one a month or 1-4 times per season	
		Change when they are worn out	
10	When do you change into clean clothes?	Right away	
		Later at the end of the day	
		Next day or later in the week	
11	When do you shower after spraying pesticides?	Right away	
		Later at the end of the day	
		Next day or later in the week	
12	When do you wash your hands/arms?	Right away	
		Later at the end of the day	

Next day or later in the week	

13 If the pesticide was spilt on you, when do you change your clothes?

Right away	
Later at the end of the day	
Next day or later in the week	

14 Do you wash the equipment used to apply the pesticides?

Yes (Please complete 14.1-14.4)	
No (Please go to question 15)	

14.1 How frequently do you wash the equipment after use?

Always	
Most of the time	
Half of the time	
Sometimes	

14.2 Where do you usually wash the equipment used to apply the pesticides?

Farm	
Home	
Others(please specify)	

14.3 When you clean the equipment, do you?

Hose down the sprayer	
Hose down the tractor	
Clean nozzle	
Rinse tank	
Or other method (please specify)	

14.4 What you usually use to clean the equipment?

Sand	
Water	
Cloth	
Water and soap	
Cleaning agent	
Others (please specify)	

15 Do you usually repair your own spraying or mixing equipment?

Yes	
No	

16 Have you ever had an incident or accident while using any type of pesticides which caused an unusually high personal exposure? e.g. spillage

Yes	
No (Please go to question 17)	

16.1 What happened? Please give more detail

____

16.2 How often has such an incident happen?

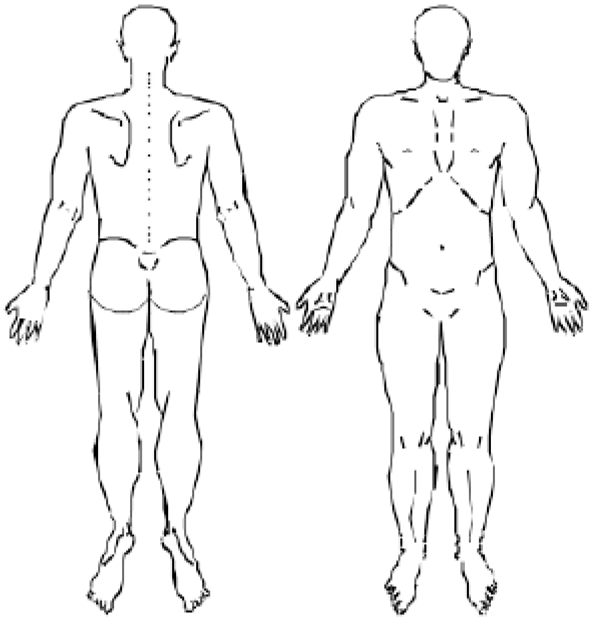
Less than one day per month	

Less than one day a week	
1-2 days per week	
3-5 days per week	
Everyday	

16.3 When was the last time an incident like this happen?
It happened : _____day, and ______months and _______years ago

16.4 What was the pesticide you were using during your highest exposure incident or accident?
____
____
____

17 When you use pesticides, which part of the body usually come into contact with pesticides? (Please mark on diagram the areas that get wet?



18 Are agricultural or commercial pesticides ever stored (even temporarily) in your home? (Mark all that apply.)

Yes, in home	
Yes, in garage	
Yes, in attached out building	
No	

PART H : EXPOSURE WHILST WORKING

Working in the field while somebody else sprays

1	Do you work in the field while someone else sprays?	Yes	
		No (Please answer question 7)	

2.	If yes how often do you do so?	Seldom (At least once per year)	
		Sometimes (At least once per spray season)	
		Often (At least once per month)	
		Always	

3.	What do you do?	Harvest vegetables	
		Weed grass	
		Packing	
		Others, please specify	

4	Do you wear any personal protective equipment?	Yes	
		No (Please answer question 5)	

4.1	How often do you replace your personal protective equipment?	Change after each use	
		Change 2 times a year	
		Change once a year	
		Use it until worn out	

5.	What do you usually wear?	Hat	
		Goggles	
		Dusk mask	
		Other type of mask	
		Face shields	
		Gloves	
		Long sleeve shirt	
		Shirt	
		Apron	
		Chemically resistant suit	
		Long trousers	
		Short	
		Chemically resistant boots	
		Shoes	
		Others(please specify)	

6	After working in the field do you wash or shower?	No	
		Hands/arms washed right away	
		Bath/shower right away	
		Bath/shower later at the end of the day	

<u>Working in a pesticide spraying field</u>

7	Do you work in a pesticide spraying field?	Yes	
		No (Please go to part I)	
8	If yes how often do you do so?	Seldom (At least once per year)	
		Sometimes (At least once per spray season)	
		Often (At least once per month)	
		Always	
9	What do you do?	Harvest vegetables	
		Weed grass	
		Packing	
		Others, please specify,	
10	Do you wear any personal protective equipment?	Yes	
		No (Please answer question 11)	
10.1	How often do you replace your personal protective equipment?	Change after each use	
		Change 2 times a year	
		Change once a year	
		Use it until worn out	
11	What do you usually wear?	Hat	
		Goggles	
		Dusk mask	
		Other type of mask	
		Face shields	
		Gloves	
		Long sleeve shirt	
		Shirt	
		Apron	
		Chemically resistant suit	
		Long trousers	

Short	
Chemically resistant boots	
Shoes	
Others(please specify)	

12 After working in the field do you wash or shower?

No	
Hands/arms washed right away	
Bath/shower right away	
Bath/shower later at the end of the day	

PART I: KNOWLEDGE ABOUT PESTICIDE USE

Num	Statement	True	False	Don't know
1.	Reading the label on the bottle of pesticide is very important before using pesticides			
2.	An organochlorine is an insecticide			
3.	Carbamate is a rat poison			
4.	Full use of personal protective equipment (PPE) is not required when using pesticides in hot weather			
5.	Areas that have been sprayed cannot be entered again immediately after spraying			
6.	A Hat is important to wear during spraying			
7.	Goggles are not personal protective equipment (PPE)			
8.	Long sleeves and long pants are to be worn during pesticide spraying			
9.	Shoes are not important to wear when spraying pesticides			
10.	Pesticide residues can be removed anywhere			
11.	Eating or drinking during the spraying of pesticides should be avoided			
12.	Cramping legs and arms is one of the symptoms of pesticide use			
13.	Gloves are very important to wear during the spraying			

PART J: PRACTICE ABOUT PESTICIDE USE

What do you do before spraying?					
Question	Always	Very often	Sometimes	Seldom	Never
1) Read the label					
2) Mixing pesticides by hand					
3) Sniffing the pesticides					
4) Mixing pesticides with other materials					
5) Checking spraying equipment					
What do you do during spraying?					
Question	Always	Very often	Sometimes	Seldom	Never
6) Drinking					
7) Eating					
8) Smoking					
9) Spraying in the morning					
10) Spraying upwind					
What do you do after spraying?					
Question	Always	Very often	Sometimes	Seldom	Never
11) Change clothes immediately					
12) Wash hands and face immediately					
13) Shower immediately					
14) Store pesticides in cabinets					
15) Dispose of pesticides in river					
16) Pesticide bottle washing in the river					

Appendix 14: Participant Information Sheet (Main Study)

MANCHESTER 1824
The University of Manchester

Pesticide exposure and general and reproductive health among farmers in Kelantan: A longitudinal study

Participant Information Sheet (PIS)

You are being invited to take part in a research study as part of a postgraduate research project to investigate the association between Organophosphate pesticide use and general and reproductive health effect among farmers in Kelantan, Malaysia. Before you decide, it is important for you to recognise why the research is being done and what it will involve. Please take time to read the following information carefully. Please ask if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

Who will conduct the research?

This study is being conducted by

a) Mr Zulkhairul Naim Bin Sidek Ahmad, PhD student, Centre for Occupational and Environmental Health, Faculty of Biology , Medical and Human Science, The University of Manchester, zulkhairulnaim.sidekahmad@postgrad.manchester.ac.uk,

b) Dr. Andrew Povey, Reader in Molecular Epidemiology, Centre for Occupational and Environmental Health, Faculty of Biology , Medical and Human Science, The University of Manchester, andy.povey@manchester.ac.uk

c) Prof Daniel Brison, Department of Reproductive Medicine, St Mary's Hospital, Manchester University NHS Foundation Trust, Manchester Academic Health Sciences Centre, Oxford Road, Manchester M13 9W, daniel.brison@manchester.ac.uk

d) Prof Martie van Tongeren, Co-Principle investigator, Centre for Occuaptional and Environmental Health, School of Health Sciences, Faculty of Biology, Medicine and Health, University of Manchester, M13 9PL,martie.J.van-Tongeren@manchester.ac.uk

What is the purpose of the research?

The aim of this study is to investigate the association between pesticides and general and reproductive health effects among farmers in Kelantan.

Why have I been chosen?

We have convenience chosen farmers aged 18 years and above from the agricultural community in Bachok, Kota Bharu, Tanah Merah, Gua Musang and Tumpat districts. The total number of participants will be approximately 150.

What would I be asked to do if I took part?

Data to be collected includes questionnaire information, a diary on self-reported symptoms, urine, saliva and semen collection (optional). There will be four appointments with an optional fifth appointment for those who want to provide a semen sample.

- During the 1st visit, you will be given an introductory letter, a participant information sheet and a consent form. The researcher will also ask when you are going to start your spraying session. You will be contacted via phone after 24 hours. If you agree to participate, you will need to sign the consent form.
- During the 2nd visit, the consent form will be collected and the interview questionnaire will be administered to collect information on demographics, lifestyle, general health, work and pesticide use, knowledge and practice about pesticide use. The interview questionnaire will take approximately 30 minutes to complete. Urine containers will be provided during this visit.
- During the 3rd visit, the researcher will ask to observe you when you are using pesticides and also record your spraying work on video .The duration of observation will be dependent on the length of spraying period and may take up to 30 minutes to complete.
- You will be asked to complete a diary for a week following your use of pesticide at the end of each working day. This will collect information on any adverse health effects and pesticide spraying. This diary will take approximately 5 minutes to complete per day.
- Urine samples will be collected twice, before and after spraying. Once analysed, the sample will be treated and disposed as clinical waste.
- During the 4th visit, we will collect your diary and urine samples. You will also be asked to collect a saliva sample in the early morning (between 8.00 to 10. 00 am). 15 minutes prior to sampling, you will be asked not to eat, smoke, drink or brush your teeth. Once analysed, the sample will be treated and disposed as clinical waste.
- During the optional 5th visit, a semen sample (optional) will be collected. You will be instructed to abstain from intercourse or any others forms of masturbation 2-3 days before collection of the semen. On the day of appointment, semen collection will take place in a private room in the hospital. You will be provided with clean and dry container. The sample will be collected by masturbation and all the semen ejaculated be collected direct into the container. Once analysed, the sample will be treated and

disposed as clinical waste. During this visit, you will be asked to complete a hospital questionnaire to collect information on semen collection, lifestyle and current general health. This will take about 10 minutes to complete.

What will happen to my personal information?

In order to undertake the research project, we will need to collect the following personal information/data about you.

- Your name, date of birth, occupation, monthly income, identification number as well as your phone number.
- Video recording, consisting of full body and surrounding environment recordings, will be taken during one day of spraying session. The recording will be used by research team for assessment for dermal exposure to pesticide.

Only the research team will have access to this information. We are collecting and storing this personal information in accordance with the UK General Data Protection Regulation (GDPR) and Data Protection Act 2018 which legislated to protect your personal information. The legal basis upon which we are using your personal information is "public interest task" and "for research purposes" if sensitive information is collected. For more information about the way we process your personal information and comply with data protection law please see our Privacy Notice for Research Participants.

The University of Manchester, as Data Controller for this project, takes responsibility for the protection of the personal information that this study is collecting about you. In order to comply with the legal obligations to protect your personal data the University has safeguards in place such as policies and procedures. All researchers are appropriately trained and your data will be looked after in the following way:

The study team at the University of Manchester will have access to your personal identifiable information, but they will pseudo anonymise it as soon as practical. This data will be retaining for use in future studies. However, your consent form and contact details, will be retained for 5 years at the University of Manchester and will be securely stored in secured university filing cabinets.

You have a number of rights under data protection law regarding your personal information. For example you can request a copy of the information we hold about you, including audio recordings or photographs. This is known as a Subject Access Request. If you would like to know more about your different rights, please consult our privacy notice for research and if you wish to contact us about your data protection rights, please email dataprotection@manchester.ac.uk or write to The Information Governance Office, Christie Building, University of Manchester, Oxford Road, M13 9PL at the University and we will guide you through the process of exercising your rights. You also have a right to complain to the Information Commissioner's Office, Tel +44303 123 1113 or https://ico.org.uk/global/contact-us/email.

Will my participation in the study be confidential?

Your participation in the study will be kept confidential to the study team and those with access to your personal information as listed above.

- All the paper data will be transferred from Malaysia to UK by an established international courier. Precautions will be taken to ensure confidentiality of the data and to ensure data are stored securely. For example; 1) all participants will be assigned a specific code so that name of the participants will not be appear on the questionnaire, 2) all the data collected will be accessed by the researcher and the research team only and 3) data will be stored on the password protected personal devices.
- For video recording, personal information will be removed in the final transcript and only the research team will have access to this information. All the faces or identifying material of the participants in the video recording will be blurred by the researcher before transported to UK. The video recording will be deleted after analysis.

What happens if I do not want to take part or if I change my mind?

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time without giving a reason and without detriment to yourself.

Will my data be used for future research?

When you agree to take part in a research study, the information about your health may be provided to researchers running other research studies in other organisations such as universities, NHS organisations or companies involved in health and care research in this country or abroad. This future research will not be incompatible with this research project and will concern occupational health. . Your information will only be used by organisations and researchers to conduct research in accordance with the UK Policy Framework for Health and Social Care Research.

This information will not identify you and will not be combined with other information in a way that could identify you. The information will only be used for the purpose of health and care research, and cannot be used to contact you regarding any other matter or to affect your care. It will not be used to make decisions about future services available to you.

Will the participants will be informed if abnormal semen analysis results?

We are unable to provide you with the results of the semen analysis but if you are concerned about your fertility due to increased awareness from taking part in this study then we would recommend that you consult with a health professional.

Will I get paid for participating in this study?

Yes, compensation for your time and inconvenience will be given at the end of the study. For those who not provide semen sample the amount is RM 100. Meanwhile, for those who provide semen sample the amount is RM 200 to cover additional cost for food and transportation.

What is the duration of my participation?

Details on the duration of the study include 30 minute for interview, 10 minute for hospital questionnaire, 5 minute for diary symptoms, 30 minute for video recording 10 minute for urine and saliva sample collection and 1 day for semen sample collection. The total duration of the research from consent to final visit will be around 2 - 3 weeks.

Where will research take place?

The research will be take place in Bachok, Kota Bahru, Tanah Merah and Tumpat, Kelantan, Malaysia. The venue for interview question, self-reported diary, and urine and saliva sample collection will be at home, video recording will be at farming area and semen sample will be at respective hospitals. Further analysis of data will be done at The University of Manchester, United Kingdom.

Will the outcomes of the research be published?

We will publish the results in a scientific journal and present them at scientific meetings. We can send you a short communication about our findings, if you wish.

Who has reviewed the research project?

The project has been reviewed by the University of Manchester Research Ethics Committee 1.

What if I want to make a complaint?

If you have a minor complaint then you need to contact the researcher in the first instance.

Dr. Andrew Povey, Reader in Molecular Epidemiology, Centre for Occupational and Environmental Health, Faculty of Biology , Medical and Human Science, The University of Manchester, andy.povey@manchester.ac.uk or by telephoning +441612755232

If you wish to make a formal complaint or if you are not satisfied with the response you have gained from the researchers in the first instance then please contact

The Research Governance and Integrity Manager, Research Office, Christie Building, University of Manchester, Oxford Road, Manchester, M13 9PL, by emailing: research.complaints@manchester.ac.uk or by telephoning +44161 275 2674.

What Do I Do Now?

If you have any queries about the study or if you are interested in taking part then please contact the researcher

Mr Zulkhairul Naim Bin Sidek Ahmad, PhD student, Centre for Occupational and Environmental Health, Faculty of Biology , Medical and Human Science, The University of Manchester, zulkhairulnaim.sidekahmad@postgrad.manchester.ac.uk, Tel: +60172341457

This project has been approved by the University of Manchester's Research Ethics Committee [UREC ID 439]

Appendix 15: Consent Form (Main Study)

MANCHESTER 1824
The University of Manchester

CONSENT FORM

(VERSION 4; 29/06/2018)

Pesticide Exposure and general and reproductive health among farmers in Kelantan: A Longitudinal Study

If you are happy to participate please complete and sign the consent form below

	Initials
I confirm that I have read the attached information sheet (Version 4, Date 29/06/2018) on the above project and have had the opportunity to consider the information and ask questions and had these answered satisfactorily.	
I understand that my participation in the study is voluntary and that I am free to withdraw until the data is pseudo anonymised without giving a reason and without detriment to myself. I understand that it will not be possible to remove my data from the project once it has been pseudo anonymised and forms part of the data set. I agree to take part on this basis	
I agree to my work being observed and video-recorded during working day.	
I agree to give urine samples for this study and I know how they will be collected. I understand that the samples will be used for medical research and after use the samples will be treated and disposed as clinical waste.	
I agree to give a saliva sample for this study and I know how it will be collected. I understand that the sample will be used for medical research and after use the sample will be treated and disposed as clinical waste.	
I understand that providing semen sample is optional and I agree to give semen sample for this study and I know how it will be collected. I understand that the sample will be used for medical research and after use the sample will be treated and disposed as clinical waste.	
I understand that the sponsors of this study may make my urine, saliva and semen samples available to other researchers for future research and that this may include researchers working abroad. I give permission for these individuals to have access to my sample.	
I understand that results from the biological samples will be used only for research purposes and not for clinical diagnosis.	
I agree that any data collected may be published in anonymous form in academic books, reports or journals	
I agree that the researchers may retain my contact details in order to provide me with a summary of the findings for this study	
I agree to take part in this study	

Data protection

The personal information we collect and use to conduct this research will be processed in accordance with date protection law as explained in the Participant Information Sheet and the Privacy Notice for Research Participants.

Name of participant
___________________________________ Signature: __________
Date: ______________

Name of person taking consent
___________________________________ Signature: __________
Date: ______________

Version 4;29/06/2018 **Page 1**

Appendix 16: Instructions leaflet for urine collection

MANCHESTER 1824

The University of Manchester

INSTRUCTIONS FOR COLLECTING URINE SAMPLE

Please read these instructions carefully

Using the sterile 60ml specimen container given to you by the research team, allow the first part of the urine stream to be passed down the toilet, and then catch the rest in the sample bottle.

Put the sample in your freezer and give your sample to the researcher when they visit. Please inform them if the sample is from the first passing of the day.

Appendix 17: Instructions leaflet for semen collection

MANCHESTER 1824

The University of Manchester

<u>INSTRUCTIONS FOR COLLECTING SEMEN SAMPLE</u>

Please read these instructions carefully

Using the sterile 20ml specimen container given to you by the research team, The specimen should be obtained after 2 to 3 days of abstaining from ejaculation. Wash hands and penis thoroughly and rinse well to remove soap residue. Please do not use lubricant. Ejaculate directly into the sterile container. Be sure that the collection is complete and that the entire specimen is collected, especially the first portion. If any portion of the sample spills, please report this to the lab technician.

Appendix 18: Instructions for collecting of saliva sample

MANCHESTER 1824
The University of Manchester

COLLECTION OF SALIVA SAMPLE

Please follow the instructions carefully.

1) Do **NOT** eat, drink, smoke and brush teeth 15 minutes prior to giving a saliva sample.
2) Rinse your mouth with water and wait for 10 minutes.
3) Spit into the collection tube until the amount of saliva reaches the fill line.
4) Screw on the cap of the collection tube to close it tightly.
5) Please keep the filled collection tube in a refrigerator until the research team comes and picks up the sample from your house.

Appendix 19: EFS

VARIABLES AND WEIGHT FACTORS BASED FOR AHS AND EFS PESTICIDE EXPOSURE INTENSITY SCORES ALGORITHM

Variables	Malay study questions
Application method Weight factor based on AHS Hand spray (9) Backpack (8) Mist blower/fogger (9) Boom on tractor (3) Boleh tak power (7) Weight factor based on EFS Knap-sack spray (manual) or (motorized), always (8) Knap-sack spray (manual) or (motorized), most of the time(6) Knap-sack spray (manual) or (motorized),, half of the times (4) Knap-sack spray (manual) or(motorized), , sometimes (2)	7. What application methods do you mainly use when you apply pesticides? ☐ Backpack sprayer ☐ Power sprayer ☐ Hand gun sprayer ☐ Others (please specify)………………………
Indoor /outdoor application Weight factor based on EFS Indoor (5.5) Outdoor (1)	All outdoor
Mixing of pesticides	6. Do you mix the pesticide as well ? ☐ Never

Weight factor based on AHS if [Mix] = Never mixed then score = 0 if [Mix] = Mixed then score = 9 Weight factor based on EFS No then score =0 Mixing <50 % =2 Mixing 50-75% =3.5 Mixing >75% = 5	☐ <50% of the time ☐ >50% of the time
Enclosed/open tank Weight factor based on AHS/EFS if [Enclosed] = Yes then score = 0.5 if [Enclosed] = No then score = 1.0	6.1 If you mix, do you use an enclosed mixing system? ☐ Yes ☐ No
Cleaning of spraying equipment Weight factor based on EFS No cleaning then score=0 Sometimes =1.25 Half of the times =2.5 Most of the time =3.75 Always = 5	14 Do you wash the equipment used to apply the pesticides? Yes/No 14.1 How frequently do you wash the equipment after use? Always/ Most of the time/Half of the time/sometimes
Amount pesticide used per application/applicator	
Use PPE Weight factor based on AHS **PPE-0** (0% PROTECTION): Never used PPE or hat only	8. Do you use safety/protective equipment during use pesticides ☐ Yes ☐ No 9. What do you usually wear while applying pesticides? (please tick all boxes that apply) ☐ Hat ☐ Goggles

PPE-1 (20% PROTECTION) Dust mask or full face shields or goggles or fabric/leather gloves or apron or cloth overall **PPE-2** (30% PROTECTION) Cartridge respirator or gas mask or chemically resistant boots or disposable outer clothing (Tyvek) **PPE-3** (40% PROTECTION): Chemically resistant rubber gloves **PPE-0** = 1.0 **PPE-1** = 0.8 **PPE-2** = 0.7 **PPE-3** = 0.6 **PPE-1 & PPE-2** = 0.5 **PPE-1 & PPE-3** = 0.4 **PPE-2 & PPE-3** = 0.3 **PPE-1 & PPE-2 & PPE-3** = 0.1 <u>Weight factor based on EFS</u> **PPE-0** (0% PROTECTION) =1 Never used any PPE **PPE-1** (35% PROTECTION)= 0.65 Glove only or one or more of hats/boots/handkerchief **PPE-2** (45% PROTECTION) = 0.55 Gloves and overall **PPE-3** (55% PROTECTION) = 0.45	☐ Dusk Mask ☐ Other **type of mask** ☐ Face shields ☐ Gloves ☐ Long sleeve shirt ☐ Shirt ☐ Apron ☐ Chemically resistant suit ☐ Long trousers ☐ Short ☐ Chemical resistant boots ☐ Shoes

Gloves, overall and boots **PPE-4** (65% PROTECTION) =0.35 Gloves, overall, boots and respirators **PPE-5** (75% PROTECTION) =0.25 Gloves, overall, boots, respirators and goggles	
Replacement of PPE <u>Weight factor based on AHS</u> Fabric/leather gloves and Change after each use then score (1.0) Change once a month or 1–4 times per season then score (1.1) Change when they are worn out (1.2) <u>Weight factor based on EFS</u> Substitute after each use =1 Substitute 2 times a year =1.1 Substitute once a year =1.15 Use it until worn out =1.2	9.1 . If you use fabric gloves, how often do you replace old gloves ? ☐ Change after each use ☐ Change one a month or 1-4 times per season ☐ Change when they are worn out
Hygienic measures <u>Weight factor based on AHS</u> **Hyg-1**: (80% protection; score = 0.2) if [Change clothing] = Right away; or always use disposable clothing	10 . When do you change into clean clothes? ☐ Right away ☐ Later at the end of the day ☐ Next day or later in the week 11. When do you shower after spraying pesticides?

and [Wash or shower] = Hands/arms washed right away; Bath/shower right away; or Bath/shower at lunch **Hyg-2:** (60% protection; score = 0.4) if [Change clothing] = Right away; or use disposable clothing and [Hand wash/shower] = Bath/shower at the end of the day or if [Change clothing] = At lunch; or at the end of the day and [Hand wash/shower] = Hands/arms washed right away; Bath/shower right away; or Bath/shower at lunch **Hyg-3** (40% protection; score = 0.6): if [Change clothing] = Right away; or use disposable clothing and [Hand wash/shower] = Hand/arms only at the end of the day or if [Change clothing] = At lunch; or at the end of the day and [Hand wash/shower] = Bath/shower at the end of the day or if [Change clothing] = At the end of the next day; or later in the week	☐ Right away ☐ Later at the end of the day ☐ Next day or later in the week 12. When do you wash your hands/arms? ☐ Right away ☐ Later at the end of the day ☐ Next day or later in the week 13. If the pesticide was spilt on you, when do you change your clothes?? ☐ Right away ☐ Later at the end of the day ☐ Next day or later in the week

and [Hand wash/shower] = Hands/arms washed right away; Bath/shower right away; or Bath/shower at lunch **Hyg-4** (20% protection; score = 0.8): if [Change clothing] = At lunch; or at the end of the day and [Hand wash/shower] = Hands/arms washed at the end of the day or if [Change clothing] = At the end of the next day; or later in the week and [Hand wash/shower] = Bath/shower at the end of the day **Hyg-5** (No protection; score =1.0): if [Change clothing] = At the end of the next day, or later in the week and [Hand wash/shower] = Hands/arms only at the end of the day **Spill** (Changing clothes after a spill): if [Spill] = Right away then score = 1.0 if [Spill] = Always use disposable clothing then score = 1.0 if [Spill] = At lunch then score = 1.1 if [Spill] = At the end of the day then score = 1.2 if [Spill] = At the end of the next day then	

score = 1.4 if [Spill] = Later in the week then score = 1.8 Weight factor based on EFS No wash and shower =1 Immediately wash and shower =0.5 Take shower just after =0.6 Immediately wash hands =0.8	